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CONTROL OF UNIVERSITY EXPENDITURE

IN a memorandum of May 28, 1952, the Treasury rejected the recommendation made by the Select Committee on Estimates in its fifth report for the Session 1951–52 that the Comptroller and Auditor General should have the right to inspect the books and accounts of universities in Great Britain so far as these relate to money advanced by means of non-recurrent grants for capital development. The Treasury pointed out that the Committee of Public Accounts is also concerned to see that all the funds of a grant-aided body are subject to the scrutiny of the Comptroller and Auditor General, and does not select one particular sort of grant for this treatment. The criticism was not construed, however, as suggesting that non-recurrent grants to universities could be treated separately from recurrent grants. The memorandum reiterated the view that Treasury control over non-recurrent as well as recurrent grants should be exercised on broad lines, and that questions of detail should be left to the University Grants Committee. The Treasury was satisfied that the latter Committee, with the assistance of its Works and Building Sub-Committee and of the Ministry of Works, scrutinizes critically the plans of new buildings for which grant aid is sought ; that the universities are required to put grant-aided work out to tender, and to accept the lowest tender unless they can satisfy the University Grants Committee that there is good reason to the contrary ; and that schedules of equipment for new buildings receive expert scrutiny from the appropriate sub-committee of the University Grants Committee. Furthermore, the Treasury emphasized its view that while the books and accounts of any new bodies receiving public grants should be subject to inspection by the Comptroller and Auditor General, the introduction of such procedure might create difficulty with some old-established institutions, such as the universities, which had been receiving grant-in-aid for many years.

It would seem that both the Select Committee on Estimates and the Committee of Public Accounts have accepted the view of the Treasury so far as recurrent grants are concerned ; but in its third report for the Session 1952–53 (No. 203 ; pp. 38 ; London : H.M.S.O. ; 1*s.* 3*d.* net), the Committee of Public Accounts again presses the view that the present system of controlling non-recurrent capital grants falls short of what Parliament is entitled, or accustomed, to expect ; and urges that in future the books and accounts of the universities relating to expenditure of grants for non-recurrent purposes should be open to inspection by the Comptroller and Auditor General. It agrees that the autonomy of the universities must be preserved, but is unconvinced that their independence would be prejudiced by the step proposed.

In a Minute of November 18, 1952, in which the Treasury stated that it is difficult to see what purpose the proposed inspection could serve which is not already covered by the existing audit of university accounts, it was also remarked that the question

whether due economy had been exercised inevitably raised questions of academic policy, and for this reason the Treasury had hitherto taken the view that its control over non-recurrent as well as of recurrent grant should be exercised on broad lines and that questions of detail should be left to the University Grants Committee. It also appeared from this Minute that the University Grants Committee has itself disallowed in assessing grants certain costs incurred by the universities.

The Committee of Public Accounts takes the surprising view that such action by the University Grants Committee supports its own argument for independent inspection of accounts, though it could equally be taken as evidence that the Treasury point of view is right and that inspection would serve no purpose. No fresh evidence in favour of such an opinion is advanced by the Committee, although, apparently on the sole ground that the Treasury was unaware what instructions were issued to the auditors of the universities' accounts, the Committee held that it could not give Parliament an unqualified assurance that there is no irregularity or abuse, and that the grants have been spent on the purposes for which they were voted, with due regard to the elimination of waste and extravagance. "Such assurance in their opinion can best be given through the Comptroller and Auditor General, whose approach to these matters is different from that of the professional auditor." The term 'best' is used, but it would seem that 'only' is meant. The argument is thin and unconvincing; but the report is disturbing, less because its lack of perspicacity reflects on the ability and outlook of the Committee itself, than because the Committee itself is to some extent a microcosm of the House of Commons. The proposal to upset the present admirable but delicately balanced financial relationship between Government and the universities of Great Britain will doubtless be once again firmly rejected, as it should be. That it should still be advanced by a representative committee of the House of Commons, even if that committee is charged with the responsibility of watching the public purse, suggests that there is lack of clear understanding, on one hand, of the work and functions of the universities, and, on the other, of the limitations and comparative functions of executive and representative bodies.

Under its terms of reference, the University Grants Committee is responsible for advising the Government on the administration of Parliamentary grants in aid of the universities, and Parliament, on those sound principles so clearly defined by J. S. Mill, has refrained from all attempts to supervise the spending of this money in detail. It has entrusted that responsibility to a group of men with close knowledge of the universities and of the academic standing that commands the confidence both of the Government and of the universities themselves. These men possess the knowledge enabling them to determine in detail the proper objects of academic expenditure, the effect of particular proposals on the balance of studies, of teaching and of research. If they are found not to possess the integrity to use that knowledge wisely, then the elimination of waste and extravagance, of irregularity or abuse, will not be secured by interference from those who do not possess such knowledge: the remedy lies in replacing them by others who possess both the knowledge and the integrity. There is, of course, no suggestion in this or in earlier reports of any lack of confidence in the integrity of either past or present members of the University Grants Committee. The trouble is probably rooted rather in over-confidence in the omniscience of either a Minister or a government official. On matters of broad policy, the Government may, and does, give some guidance to the University Grants Committee, as, for example, in regard to the nation's requirements for particular types of academically trained men and women; a Government Department can indicate some specific or broad fields in which new knowledge is desirable, but wisely the arrangements by which such ends should be achieved are left to the Committee and the universities themselves.

The report is disturbing for the indication it affords that there is some lack of public understanding of the position of the universities in Great Britain, of the way they function, and their true relations to the Government. Without that understanding, such a system as the University Grants Committee will manifestly become unworkable, and all the sooner in view of the demand for closer accountability which the growing dependence of the universities on public support is likely to engender. The ill-judged recommendation from the present Committee of Public Accounts and its support from the Select Committee on Estimates may in part be due to the lack of experience, on which Mr. Basil Chubb laid such stress in his study of the control of public expenditure, or to the increasing difficulty, in view of existing demands on Parliamentary time, of finding members with the requisite ability, judgment and experience to serve on such committees. It certainly reflects lack of public understanding of the functions and purpose of the universities on the part of those who are elected to Parliament.

The last quinquennial survey of the University Grants Committee and the subsequent discussion at Cambridge during the Congress of Universities of the Commonwealth are well calculated to increase such public understanding. It might be emphasized that such reports are the material to which any such bodies as the Estimates and the Public Accounts Committees should turn in the first instance as a basis for forming a sound judgment as to the wise expenditure of public funds by the universities. Accounts are only one method—and that not the first method—of determining whether the nation is getting full value for its expenditure of some £20 millions and more. As Sir Frank Tribe told the members of the Institute of Public Administration, no examination based on figures alone can lead to a proper judgment on the efficiency of a concern or a Department of State.

The tentative suggestions which Sir Frank Tribe made in that lecture four years ago for criteria and possible bases of comparison warrant further careful

study; but their value, whether in regard to the grant-in-aid of universities or in regard to national expenditure in general, is likely to be assessed more accurately by expert administrators than by a Select Committee. What is even more disturbing than the lack of understanding of the functions of the universities is the evidence that Parliament fails to grasp the essential limitations and the true function of a representative body as against the executive. "The proper duty of a representative assembly in regard to matters of administration," wrote Mill, "is to take care that the persons who have to decide them shall be the proper persons." It is only when this limitation is kept in mind that a Select Committee can perform usefully and efficiently that vital function of a public watch-dog, putting the light of publicity on the acts of Government Departments and compelling a full exposition and justification of anything which appears questionable, and censuring fearlessly where required. That function, however, will not be performed effectively unless both the Committee and the House understand clearly the limits within which it can be exercised: criticism, and even censure, lose much of their force and weight if the body making them has lost credit and reputation by making representations on matters in which it manifestly has not, and could not be expected to possess, the requisite depth of knowledge. Similarly, the effective control of public expenditure demands on the part of Parliament a readiness to accept and to act on responsible and independent criticism, and not to impute political prejudice even when findings are, as has already happened and will doubtless happen again, counter to the doctrines of a political party.

It may be taken for granted that, in view of Mr. Butler's remarks to the Congress of Universities of the British Commonwealth on July 14 regarding academic freedom, the Government is unlikely to accept any recommendation which will threaten that freedom or disturb the existing mutual confidence between Parliament and the executive and the universities. Moreover, the chairman of the Committee of Public Accounts, Mr. G. Benson, has now explained, in a letter in *The Times*, that the proposal is not that the Government, much less the Comptroller and Auditor General, should "determine in detail the proper objects of scholarly expenditure". The proposal, he now explains, is simply that the Comptroller and Auditor General should examine the methods of contracting and of recording and controlling expenditure in order to judge whether these are reasonably designed and properly applied to ensure effective safeguards against waste and extravagance or other abuse. The proposed examination would be directed to the broad question whether the financial arrangements are likely to provide the building required by the policy-makers without waste or extravagance.

This disclaimer of any concern with academic policy puts a different complexion on the proposal. It could not be gathered from the report itself that no more was intended than a review of the methods used to secure effective control of the cost of building works, an objective notoriously difficult to achieve, as Mr. Benson rightly points out. This experience suggests that review by the Public Accounts Committee of such expenditure has enabled the Ministry of Works to strengthen its own control over its building expenditure, and thus has led to increased economy. This explanation should have found a place in the report itself. If, as it stands, the report does some undeserved harm to the reputation of the Committee, real good may have been done by this further demonstration of the need for more public understanding of the work of the universities and of the mechanism of public control and the functions of a representative body. It cannot be too clearly stated to-day, with the increasing rigidity of control over the individual member which a close balance between political parties almost inevitably entails, that Parliamentary control, whether over expenditure or policy, cannot be either wise or effective if members sacrifice their judgment to the majority opinion. To-day, as in Burke's time, the integrity and vitality of democratic institutions depend ultimately on the extent to which members of Parliament, and like assemblies, in the full House or on its committees, preserve and act on their own unbiased opinion, their mature judgment and their enlightened conscience.

SCIENCE AND FAITH

Modern Science and Modern Man

By James B. Conant. (Bampton Lectures in America No. 5, delivered at Columbia University.) Pp. iv+111. (New York: Columbia University Press; London: Oxford University Press, 1952.) 14*s*. 6*d*. net.

Science and Faith To-day

By John Baillie, Robert Boyd, Donald Mackay and Douglas Spanner. Pp. 60. (London: Lutterworth Press, 1953.) 3*s*. net.

IN four essays on science and technology in the past decade, the changing scientific scene, 1900–50, science and human conduct, science and spiritual values, which constitute this book, Dr. J. B. Conant ranges over a wide field but is never superficial. His essays attempt to provide some interpretation of the significance for the whole social pattern of Western civilization of developments in physical science during the past twenty years, and including the effect of the impact of modern science on the philosophical presuppositions of the average enlightened citizen of a modern democracy. They are addressed, not so much to the professional philosopher or scientist, as to the educated citizen, whether graduate or not, and should be appreciated as much in Great Britain as by the audience at Columbia University to which, as the Bampton Lectures, they were first delivered last year.

Dr. Conant suggests first that the changed status of the scientist is one of the major significant features of the past decade. The scientist is no longer thought of as a man in an 'ivory tower' but as a miracle-worker who can bring about tremendous transformations of man's relations to his material surroundings. The scientist has displaced the inventor in the mind of the general public as the prime mover of technology, and thus has arisen the current fallacy which tends to equate the scientist with a magician. Dr. Conant recognizes the danger of this

fallacy; but he does not suggest that it is serious enough to offer any real threat to the advance of science. He is much more concerned about another major development—the changed relation of many scientists to organized society, that is, the government, and the effect of secrecy. Those who are competent to discuss the future of atomic energy, he points out, cannot do so because of security regulations: it is impossible to-day or in the foreseeable future to have a frank, rational, searching discussion of the industrial uses of atomic energy. Secrecy and science are fundamentally antithetic propositions.

It is important that the general public should understand the consequences of the union of secrecy and applied nuclear physics; but Dr. Conant accepts that union as inevitable for a long time to come. At the same time, he admits the risk that so large a proportion of scientific resources may be devoted to work in this field that the traditions that have made science possible will be threatened. Really significant advance has come not from empiricism but from new theories, and the essential element in the advance of modern science has been a diminishing degree of empiricism and the increase of theory.

Dr. Conant is content to point in passing to the danger to the advance of science which such conditions represent and to insist on the importance of the public being aware of the danger. He is much more concerned with the changed attitude of the public towards science and the altered viewpoint of the scientist towards science which is the theme of his second lecture; but, in suggesting that we are concerned with a break in the continuity of a line of argument and in challenging the claim that science is teaching us more about the nature of physical reality, Dr. Conant enters on debatable ground. Indeed, his scepticism seems inconsistent with his previous claim that the advance of science is marked by a diminishing degree of empiricism.

It is true, as he points out, that the failure to settle by experiment the validity of the wave theory versus the corpuscular theory of light has been a prime factor in changing the scientific point of view, and Dr. Conant defines science as "a series of interconnected concepts and conceptual schemes arising from experiment and observation and fruitful of further experiments and observations". This definition leads him to suggest that the test of a scientific theory is its fruitfulness, or its ability, in J. J. Thomson's words, "to suggest, stimulate and direct experiment". A scientific theory, he argues, is not even the first approximation to a map; it is not a creed but a policy—an economical and fruitful guide to action by scientific investigators.

Dr. Conant does not make his distinction quite clear. A scientific theory is admittedly not a creed, and it may be useful to regard scientific theories as guides to human action and thus an extension of common sense. Dr. Conant, in fact, stresses the way in which the results of scientific activity have become intermeshed with common-sense ideas when, later, he points out that scientific concepts are so much a part of the equipment of men and women in our culture that they are used both consciously and unconsciously in making decisions that we call ethical or moral. But both a map and a policy must be credible if a consistent course is to be set or a firm policy pursued, and Dr. Conant seems to overlook the sizable act of faith that is involved, no matter how ready we may be to discard a theory. Nor is it easy to believe that scientific work would be pursued with quite the same ardour if it were as divorced from reality as Dr. Conant implies, and if the investigator did not believe he was gaining some insight into the nature of the physical world.

The importance of this point is perhaps brought out more clearly in a little book, "Science and Faith To-day", which covers much of the ground that Dr. Conant covers and has more in common with his book than might appear at first sight. Dr. John Baillie, in the first of the five chapters of this book, which constitutes a shortened version of an address he gave to the British Association at Edinburgh in 1951, insists quite as strongly as Dr. Conant that we are concerned with two diverse ways in which the whole territory of our human experience may be approached and explored (using the simile which Dr. Conant rejects). Like Dr. Conant, he recognizes how largely our general outlook on life has been affected by the scientific approach to things. As Dr. Conant admits, regarded as guides to human conduct, common-sense ideas and scientific concepts interpenetrate to such an extent that no one can say where one begins and the other ends, and any attempt to draw a sharp line between common-sense ideas and scientific concepts is not only impossible but even unwise.

Dr. Conant rightly adds that the notion that the scientist is a cool, impartial, detached individual is absurd and to be rejected, and that this interpenetration means that even in his laboratory the scientist cannot escape making judgments of value. It is not enough, however, to make the point that the antithesis between science and value-judgments is false and to ignore the nature of scientific undertakings and the motivation of many scientists. Unless, as Dr. Baillie points out, the conduct of affairs is determined by some belief in moral and spiritual values, even science itself is threatened. The irresponsible exercise of power is fatal to the continuance of science as of civilization; and the responsible exercise of power is an act of faith.

Dr. Conant does, it is true, in his last lecture face this problem of spiritual values. He admits that the scientific investigator has to believe as well as to doubt and question, and that, in regard to many phenomena, as men of action we require at least provisional beliefs. Nor does he suggest that the benefits that flow from scientific investigations are all material. He believes that science creates an atmosphere encouraging to those who believe that man is not merely a social animal: the history of the past three centuries is a record of the flowering of the creative powers of the human mind as well as of achievement in the manipulation of ideals, and the lectures close on a note of humility.

Nevertheless, Dr. Conant's book seems to need the message which Dr. Baillie, Dr. Robert Boyd, Dr. D. Mackay and Dr. D. Spanner convey in their broadcast talks to complete his interpretation. Dr. Boyd, for example, puts even more clearly the point that our value-judgments are, and must be, made as complete men, not just in our capacity as scientists. Dr. Mackay, who likewise emphasizes the personal character of religious experience, clears away some of the confusion which Dr. Conant's analysis has left with his distinction between the language of the actor and the language of the observer, and his warning against using words or concepts defined for different logical backgrounds; the fact that Dr. Spanner's approach to the limitation of science is from a direction entirely different from Dr. Conant's helps

to throw a fresh light on this question of the relation between science and what Dr. Conant terms spiritual values.

Dr. Conant himself appears to recognize as clearly as Dr. Baillie and his fellow-writers that we are concerned not with two separable regions of experience but with two complementary aspects of it. He would seem to agree again with Dr. Baillie that the supreme values or certainties in music and in literature, for example, are those which science can do nothing either to suggest or to establish. He appears to agree also that by exposing the manner of Nature's operations science enables us to harness those operations to attain ends which we spiritually discern to be worth while, and that scientific knowledge is worth having for its own sake even when it leads to no practical result; but he seems more sceptical as to the third service which Dr. Baillie claims that science renders: it helps to provide an element of otherness and conflict which is a necessary part of our spiritual discipline.

Dr. Conant himself recognizes the variety of human experience and goes far to meet Dr. Baillie's point when he concedes that the scientist himself has to exercise faith as well as to probe and criticize. The whole spirit of this little book on science and faith, with its insistence that science and faith are complementary conceptions or aspects of a life which has to be lived as a whole, and its refusal to accept limitations on scientific inquiry or to stifle faith, gives a new meaning and direction to the traditional conflict between science and faith. They are seen rather as two complementary elements in the ceaseless search for truth, and these essays, which cover so much ground common to Dr. Conant's book, seem well designed to complete an explanation and interpretation of the place of science in the modern world which Dr. Conant attempted but just failed to unfold completely and satisfyingly. R. BRIGHTMAN

DEVELOPMENTS IN PHYSICS

Reports on Progress in Physics

Vol. 15 (1952). Executive Editor: A. C. Stickland. Pp. iv+338. (London: Physical Society, 1952.) 50*s*. net; to Fellows, 27*s*. 6*d*. net.

SINCE its introduction in 1934, fifteen volumes of the "Reports on Progress in Physics" have appeared, and a wide variety of individual subjects have been reviewed, some several times, as the cumulative author and subject indexes for Vols. 1–15, appended to Vol. 15, illustrate. Although the "Reports" seem to be getting more and more specialized each year—perhaps too specialized—no physicist who wishes to keep up to date with advances in the many rapidly developing fields of physics can really afford not to peruse these volumes.

Vol. 15 contains nine articles of varying length and merit, and the subjects treated, in which both theoretical and technological aspects are represented, cover a wide field. The longest, some seventy pages, and undoubtedly the best article in the volume, is by G. V. Raynor and is concerned with the band structure of metals. It is significant that although there are several recent monographs on this particular subject, the author has no need to refer the reader to them, except when some specific aspect, such as the behaviour of semiconductors or ferromagnetism, is deliberately omitted from consideration. In the introductory section the major advances in the development of the electronic theory of metals since the early Lorentz theory are rapidly, but very skilfully, recapitulated, and then the major part of the remainder of the report is devoted to a review of the electronic structures of typical classes of metals. The mathematical complexity of the subject is carefully avoided, without any loss of clarity, and no physicist need be afraid that through lack of familiarity with the subject he will be unable to follow Raynor's exposition. The research worker, too, will be pleased to read that, though qualitatively the nature of metallic substances is now clear and in many cases there is good agreement between experiment and theory, considerable gaps, which are all carefully detailed and explained by Raynor, exist and are well worthy of his attention.

Turbulent motion in fluids is treated in a forty-page article by G. K. Batchelor and is the third on the subject to appear in the "Reports". It is sixteen years, however, since the last report, and in that time the literature on turbulent motion has more than doubled. In addition, much progress has been made in the clarification of the essential physical nature of the problem and in the recognition of the almost ubiquitous presence and importance of turbulence in physical problems. Nevertheless, the phenomenon of turbulence is still much of a mystery, and, to quote Dr. Batchelor, what has been achieved is that "we can state what we do not know more closely than we could sixteen years ago". The main article is followed by a short appendix in which the principal advances in measuring technique, particularly of the hot-wire anemometer, is summarized by A. A. Townsend.

Nuclear physics is represented by two articles. Range–energy relations are discussed by A. E. Taylor, of the Atomic Energy Research Establishment, Harwell, and high-energy neutron–proton and proton–proton scattering data are analysed by R. S. Christian, formerly of the Los Alamos Scientific Laboratory, New Mexico. These two articles obviously are not of general appeal; but the mass of experimental information which has been accumulated by using charged particles accelerated to high energies of 300 MeV. or more, or heavily charged particles in the form of fission fragments, is important and may give a lead to a more comprehensive and satisfactory understanding of nuclear forces than exists at present.

A report by A. Fairweather, F. F. Roberts and A. J. E. Welch, of the Post Office Research Station, is devoted to a description of the preparation and the physical and chemical structure of ferrites and to a brief outline of Néel's theory of ferrimagnetism. Ferrites first attracted engineering interest as non-metallic ferromagnetic materials for use at frequencies where, in the more usual metallic materials, eddy currents have undesirable effects, but they are now studied mainly in order to obtain a deeper understanding of the ferromagnetic and anti-ferromagnetic behaviours of non-metallic substances. The literature on ferromagnetism and anti-ferromagnetism is extensive, but the subject-matter is not easy to follow, and it is unlikely, in spite of the brave attempt made by the authors of "Ferrites", that any but those who already have a good grasp of the subject will benefit from reading this report.

The survey given by L. Kellner of the infra-red spectra of substances capable of forming a hydrogen bond, and of the hydrogen bond postulate, is another highly specialized, though quite brief, report. This is followed by a useful description, by K. I. Mayne, of

recent theoretical work on the improvement in design of spectrometers and of their application, with enhanced sensitivity, in geological and biological problems and in nuclear chemistry.

In the remaining two articles electrical phenomena are dealt with. The galvanomagnetic effects (the Hall field and magneto-resistance) in conductors are fairly well reviewed by D. K. C. MacDonald and K. Sarginson, but the report might have been improved by the expansion of the first part, the physical survey, with appropriate brief references to the theoretical problems and by omission of the second part, the mathematical treatment. Finally, there is a most interesting, but somewhat verbose and loosely written, account of travelling-wave tubes by R. Kompfner. These tubes are of importance in microwave electronics and have recently found application in communication engineering. Since the Second World War much of the progress is due to J. R. Pierce, of the Bell Telephone Laboratories, though Kompfner himself has made important contributions, and several novel types of tubes have been evolved. The fundamental principle of operation is understood, and much theoretical work has been carried out; but not all the problems have been solved, and experimental work still lags behind theory. The result of Kompfner's survey can therefore be summed up in his own words—namely, that it is impossible, at this stage, to assess the degree of importance which is to be attributed to the various discoveries, devices and developments and to put them in their proper perspective. It may be asked, therefore, whether this is the proper time for such a progress report.

S. Weintroub

TREATISE OF PALÆONTOLOGY

Traité de paléontologie

Publié sous la direction de Prof. Jean Piveteau. Tome 1: Les stades inférieurs d'organisation du règne animal; introduction, par J. Piveteau; généralités, par J. Roger, H. Tintant, C. Dechaseaux, L. Cuénot and A. Tétry; Protistes, par G. Deflandre, A. Sigal et R. Ciry; Spongiaires, par L. Moret; Cœlentérés, par J. Alloiteau et M. Lecompte; Bryozoaires, par E. Buge. Pp. vii+782+10 plates. 8900 francs. Tome 2: Problèmes d'adaptation et de phylogenèse; Brachiopodes, Chétognathes, par J. Roger; Annélides, par C. Dechaseaux et J. Roger; Amphineures, Scaphopodes, Lamellibranches, par C. Dechaseaux et G. Lucas; Gastéropodes, par H. et G. Termier; Céphalopodes, par E. Basse, G. Delépine et J. Roger. Pp. vii+790+24 plates. 9700 francs. (Paris: Masson et Cie, 1952.)

THE first two volumes of Prof. J. Piveteau's seven-volume "Traité de paléontologie" bear witness to the enormous increase in range and complexity of the subject since the last edition of the classic work of Zittel. Six volumes are now needed to cover the animal kingdom excluding man, to whom one volume is to be devoted, and in many Classes the proportion of genera listed to genera recognized is much smaller than in the older work.

Co-operation between editor and printer has resulted in the successful execution of a well-planned lay-out. In the systematic parts, family and subfamily headings in sans serif could have been made more conspicuous by insetting. The latter are particularly difficult to see. Footnotes in these sections (fortunately few in number) are also insufficiently differentiated. In all other respects the book is well produced and easy to work with, though more use might have been made of right-hand page-headings. Illustration, especially of morphological features, is abundant and the photographs of specimens give a more direct idea of the fossils than any line-drawings could convey. The post-Palæozoic corals and the ammonites are even illustrated by collotype plates—the latter quoted from F. Roman's "Les Ammonites Jurassiques et Crétacés" (1938).

Space forbids review of individual chapters, but many general points invite criticism. From Prof. Piveteau's introduction it would appear that nothing significant in palæontology has ever been done outside France (with one Belgian exception). This attitude has fortunately not affected the contributors. The chapters on general principles display that characteristically French blend of authority with enthusiasm which disarms criticism. The various topics are incompletely covered, but the freshness and vigour of the writing should inspire students to understand more about the science and to fill in the gaps by further reading. Unevenness in quality and inconsistency in detail impair the potential utility of the work. Editorial policy could have assured consistency in, for example, citation of author and date for the various systematic categories; statement of scale of magnification or reduction of figures; indication of type-species when cited (too often species are omitted altogether); and adherence to the International Rules of Zoological Nomenclature, especially as regards the use of pre-Linnean names (for example, Vol. 1, p. 666).

The introduction of new zoological names in works of reference is generally condemned; such names are easily overlooked, and there is seldom space for adequate description and discussion. Of several cases in the "Traité" perhaps the worst is on p. 593 of Vol. 1, where a new genus and species are proposed without systematic context. This new genus is not mentioned in the systematic catalogue or in the index. New family names are perhaps less objectionable in text-books, but new names at higher levels involve major taxonomic problems as well as the ethics of teaching. Students have a right to expect that the classifications presented in text-books shall claim at least a large measure of acceptance among competent authorities. A new classification of the post-Palæozoic Corals is here put forward with a persuasiveness and a wealth of illustration which command admiration, but it is doubtful whether there has been the opportunity which is desirable for criticism by interested specialists.

The chapter on the Flagellata epitomizes more than twenty years of pioneer research by M. and Mme. G. Deflandre and merits special welcome. That on the Foraminifera also displays outstanding ability. Of the remaining chapters, the majority are adequate to their purpose, but the systematic parts of those on the Lamellibranchia and Gastropoda have been too drastically shortened and the space allotted to the Rudistidæ in the former is disproportionately large.

As works of reference, these two volumes will be found more valuable on general questions than as taxonomic handbooks. The best things have the true Gallic brilliance and penetration and will endure. The weaker parts show that so formidable a task as this is not to be lightly undertaken. It is to be regretted that the books are priced beyond the reach of students.

R. V. Melville

PREVENTIVE MEDICINE ON THE FARM

At the Liverpool meeting of the British Association, Section M (Agriculture) devoted the morning of September 7 to a discussion on "Preventive Medicine among Farm Livestock" with Dr. John Hammond (Cambridge) in the chair. The prominence of animal health in the programme of this section illustrated both the close association between agriculture and veterinary science and the need for increasing animal production.

In his introductory remarks, Prof. E. G. White (University of Liverpool) defined preventive medicine as "keeping animals healthy by preventing disease" and illustrated some of the ways in which farm livestock can be protected against diseases, whether introduced at intervals from abroad (foot-and-mouth disease, anthrax, fowl pest) or established within Great Britain. Prevention, said Prof. White, is not only better than cure, it is also cheaper, which is an important advantage to the farmer.

A number of serious animal plagues were eradicated from Great Britain by restriction of the importation of animals and raw animal products, slaughter of affected animals and in-contacts, and sanitary measures. These methods are still used for some of the diseases that enter Britain from time to time, such as the serious and widespread outbreaks of foot-and-mouth disease during 1951–52 which were due to infection from Europe, possibly transmitted by migrating birds. In recent years two more notifiable diseases, parasitic mange of horses and sheep scab, have been eradicated. Protection of stock with vaccines and other biological agents is of particular value where the causal agents of disease live in the soil, as with a number of sheep diseases. Vaccination is also of great value for contagious abortion in cattle and swine fever. With internal parasites, such as liver flukes and nematodes, it may be impossible entirely to prevent animals becoming infected. The method of control is to limit the level of infestation by proper grazing practice, to control disease by strategic dosing with anthelmintics and to provide a good standard of nutrition in order to increase the host's resistance to the parasites.

Poisoning among farm animals, particularly lead poisoning in cattle caused by licking painted wood or metal objects, can usually be prevented. Fluorosis has been found to be a serious problem in the neighbourhood of certain types of industrial plant: brick works, aluminium works and some types of steel works have been incriminated. Piped main water is a valuable weapon of preventive medicine on the farm; too many farms still have to rely on wells and ponds for their water supply. This makes clean milk production and disinfection difficult, and favours the spread of disease.

The losses due to disease in livestock are difficult to assess because there are no accurate figures for disease incidence, except for the notifiable diseases. Losses certainly amount to many millions of pounds each year. Much of this loss can be avoided. Damage to hides due to the larvæ of the warble fly, for example, caused a loss of nearly half a million pounds to the Ministry of Food in 1952: the fly could be eradicated from many areas if cattle were regularly dressed with the statutory preparations.

The disease picture is continually changing. When new methods of control become effective against some diseases, others are brought to light. Thus control of trichomoniasis revealed *Vibrio fœtus* as a cause of infertility in cattle. The use of antibiotics for mastitis, vaccination for contagious abortion and several sheep diseases, and anthelmintics and insecticides for internal parasites has greatly reduced the losses from these diseases in recent years, and more attention can now be paid to the diseases that remain. Preventive medicine embraces not only those diseases that are caused by infective agents but also covers a much wider field, including the prevention of nutritional and metabolic diseases and poisoning and the avoidance of methods of breeding, housing or management that favour disease. With better control of infectious diseases there is an opportunity to devote more attention to diseases caused by factors other than infective agents.

Prof. White concluded by remarking that although the cure of existing disease and the relief of suffering are very necessary, the first duty of medicine is to prevent disease. But whereas the successes of curative medicine are easily measured, the real triumphs of preventive medicine are not, for they are the things that do not happen.

The contribution of the State to disease prevention and control, through the full-time staff of the Animal Health Division and the panel of part-time veterinary practitioners, was dealt with by Mr. J. N. Ritchie (chief veterinary officer, Ministry of Agriculture and Fisheries).

Mr. Ritchie dealt first with the notifiable diseases which owners are required by law to report to the police when they are suspected. Some of these diseases (cattle plague, bovine pleuropneumonia, sheep pox, glanders, epizootic lymphangitis and rabies) have been eradicated by slaughter of affected and in-contact animals, control of importation and movement, and sanitary measures. Modern sheep dips containing 'Gammexane' have helped to eradicate sheep scab because they necessitate only a single dipping instead of double dipping. There has been no sheep scab in Scotland for twelve years and none in England and Wales since 1951.

A wide variety of regulations exist to control the importation of animals, animal products, and goods that may convey infection mechanically from abroad; but since we must still depend to some extent on imported animal feeding-stuffs and fertilizers and on imported meat, a certain amount of risk must be accepted. Outbreaks of anthrax usually arise from imported feeding-stuffs and fertilizers, and during 1952–53 there was a particularly high incidence of the disease, especially among pigs. Three-quarters of all primary outbreaks of foot-and-mouth disease are probably caused by infected swill containing the virus in the form of waste meat from imported chilled carcases. The separation of swill from livestock until it has been boiled for one hour is a valuable method of preventing this disease, as well as swine fever and fowl pest. Swine fever is perpetuated by movements of pigs through markets and dealers' premises, and its control is fairly rapid when movement restrictions are imposed. Greater

use of vaccination would help to reduce the incidence of the disease. Fowl pest was re-introduced into Britain in 1947 with imported poultry carcases, after fourteen years freedom from infection. Control is by the slaughter of infected and in-contact birds but is hampered by the occurrence in recent years of a sub-acute form of the disease which is difficult for the farmer to detect but is very contagious.

Perhaps the greatest achievement of preventive veterinary medicine of recent years is the scheme to eradicate tuberculosis from cattle by the Attested Herds Scheme and the establishment of free-testing, eradication and attested areas. By the end of March 1953 almost four million cattle, representing 41·4 per cent of the total stock, were in attested herds. Attested areas containing some 700,000 cattle have been established in south-west Scotland, south-west Wales, Shetland and the Scilly Isles. Adjacent to the areas in Scotland and Wales are free-testing areas containing another million cattle which will soon more than double the cattle population in attested areas. Abortion due to brucellosis has been well controlled by vaccination, and that due to trichomoniasis has responded to treatment of infected cows and the use of artificial insemination.

In addition to the field-work involved in preventing and controlling disease, the Animal Health Division has a laboratory diagnostic and research service which operates from two main laboratories at Weybridge and Lasswade and from the divisional diagnostic laboratories which exist in most counties and the Veterinary Investigation Centres.

Dr. E. L. Taylor (Weybridge) introduced the subject of parasitic diseases by stating that half of the living creation is parasitic on the other half, and that the species of parasite are more numerous than the species of host on which they live. Dr. Taylor illustrated the importance of parasitic disease on animal production by discussing the losses caused by the parasitic nematodes. He presented a picture of parasitism of stock in four periods in history. In the first period, a mythical Garden of Eden, parasite and sheep lived happily together because there was plenty of room for animals to graze and so the intake of infective stages of the parasites was small. Sheep were able to maintain their worm population at a level which was compatible with health. In the second period, that of trial and error, farmers began to domesticate animals, to enrich the soil and to fence the land. Parasites flourished and losses among farm stock were severe. By a process of trial and error farmers found ways of reducing their losses. There followed the present age, the age of reason, during which knowledge of parasites and their life-histories enables man to use anthelmintics and methods of pasture management which help to reduce losses. An experiment at Weybridge with twin lambs, one of each being kept worm-free and the other infected with a moderate number of worms, showed that by the end of the year the average weight of the infested lambs was some 30 lb. less than that of their worm-free twins. This difference occurred in spite of anthelmintic treatment. Since worms are ubiquitous where sheep are kept, this difference between optimal gain and 'normal' gain is very considerable, and Dr. Taylor calculated that even if the difference amounted to only 10 lb. per lamb it would mean a loss of some 18,000 tons of meat a year.

The fourth age, the age of eradication, has hitherto seemed to be unattainable; but there is now some hope that, at least for some species of worm, it may well be reached. Experiments by Dr. Spedding at the Grassland Research Station with sheep on arable land have shown that the use of phenothiazine, together with a folding system, can enable sheep to be kept free from worms altogether. Although such a procedure may not for a long time become practicable farming practice, it nevertheless marks a beginning, and with the development of better parasiticides may well open up a method which could enable animal production to be raised to a level far higher than had been thought possible.

The symposium ended with a contribution from Mr. J. O. L. King (University of Liverpool) on the influence of animal husbandry on disease. Domesticated livestock of to-day, Mr. King said, are very different from their wild ancestors. Their greatly increased productivity demands high standards of nutrition and management and protection from bad weather. Whereas the importance of nutrition and genetics is well recognized, the influence of environmental factors on disease incidence is not given the attention it deserves. A recent study by Withers of calf losses showed that the increased mortality in the early spring is greatest in the northern half of Britain and is probably due to the adverse effects of extreme cold, wide temperature ranges, and absence of sunshine. Phillips, from a study of knackery records in West Wales, showed a great increase in cows slaughtered during April each year, which is probably a reflexion of the adverse effects of confinement indoors on an inadequate diet during the winter months. Stock require to become acclimatized to colder and more rigorous conditions, which is why farmers prefer to "go north" for stock replacements. Mr. King gave a number of illustrations of the adverse effects of sudden changes of environment on farm stock, particularly in relation to their fertility. Pigs are particularly susceptible to a cold and damp environment, and the cost of providing heat for very young pigs is well repaid by a higher survival-rate and better growth. Cattle can with advantage be given more fresh air and exercise than the conventional cowshed or stall provides. The use of covered or semi-covered yards for cattle and of open-fronted sheds for calves favours the production of healthy stock.

Ventilation of animal buildings means providing sufficient fresh air without draughts and a reasonable temperature without high humidity. Mr. King pointed out the advantages of the Belfast type of piggery, for fattening pigs, with low well-insulated sleeping quarters and yards for water and excreta which are separated from the sleeping pens by concrete baffle walls and swing doors. Such houses provide a very even temperature throughout day and night, with a maximum variation of some 12° F. With poultry kept under the intensive system, faulty ventilation is the chief error.

Mr. King concluded by advocating special attention to housing and feeding during the winter months in order to avoid the loss of condition which is so common during this period of the year.

In the discussion, Prof. J. G. Wright (University of Liverpool) mentioned the serious losses which result from cattle eating pieces of metal, such as baling wire, nails or screws. Losses from this cause are preventable. Some indication of the wide variety of such objects and the effects they produce were provided on the following day when members of the section visited the Veterinary Field Station of the University of Liverpool.

E. G. White

RECENT PROGRESS IN DIELECTRICS

IT is something of an event for Section A (Mathematics and Physics) of the British Association to devote a session to dielectrics, as occurred on September 3 during the Liverpool meeting; but both the event and its rarity are understandable. Faraday used or knew of waxes, impregnated paper, oil, rubber, resins, silk, cotton, wood, amber, sulphur, glass, ceramics, mica and quartz. A century later vulcanized rubber (ebonite) and the phenolic and allied synthetic resins (for example, 'Bakelite') had been added; but there was little fundamental change. Engineering progress had nevertheless been remarkable, with landmarks such as the first submarine cable, insulated with gutta-percha, and Ferranti's 10-kV. cable from Deptford to London, insulated with impregnated paper, of which specimens will still support 10 kV. sixty years later.

Physics entered first in the elementary theory of the macroscopic dielectric field, leading to methods of measurement which gave some quantitative assessment of the merits of a dielectric. Unfortunately, knowledge of how to achieve merit was meagre; for example, the avoidance of electrolytes, moisture, holes, impurities and heterogeneity generally. Nevertheless, again engineering achievement, based on scanty physical principles, was impressive and made possible the great developments between the two World Wars of high-voltage plant and of telecommunications. At the end of this period the theory of the solid state began to catch up with empirical acumen, so that a directed exploration of dielectrics became practicable and, fortunately, contemporary advances in chemistry and chemical engineering made possible the economic production of new materials. The transition was gradual but the theoretical physicists, among whom Prof. H. Fröhlich, of Liverpool, must always be acknowledged, undoubtedly led the way to the general principles in what had hitherto been regarded as an experimental subject.

In the opening address of the discussion, by Dr. S. Whitehead, director of the Electrical Research Association, the following were given as the main principles so far used.

(1) Certain atoms tend to be more tightly bound in combinations and are more resistant to thermal activation, ionization and chemical attachment. In suitable groupings silicon and sulphur are preferable to carbon, the halogens to hydrogen and nitrogen to oxygen.

(2) The insulating property arises from scarcity of free electrons because there is a large energy difference between the conduction zone and the highest filled zone of electrons attached to atomic groups. The structure should therefore have as few imperfections as possible where electrons can be loosely trapped.

(3) The oscillation and rotation spectra of gases are outside the electromagnetic range, but solids and liquids have a relaxation spectrum which extends from the order of 10^{10} c./s. or above down to very low frequencies. It comprises absorption regions caused by dipoles in the molecule or in impurities (1 mobile ion in 10^{12} molecules has a noticeable effect) or by an electric moment coming from asymmetry or distortion: these regions are superposed on a comparatively weak continuous spectrum derived from a distribution of relaxation times. Dipoles in liquids can be distributed in all directions, but in solids they are usually distributed in opposite senses along a few preferred directions.

(4) Electronic instability and breakdown arises from the inability of electrons to dispose, to the solid structure, of the energy gained from the electric field. If scattering centres, such as dipoles, are present, the electric strength is higher at low temperatures because of the scattering effect; but it is less at high temperatures because the loosely trapped electrons become free. A good crystal has a fairly constant electric strength, except that of the alkali halides, which increases with temperature by reason of the unusually low Debye frequencies.

Thermal breakdown comes from failure to remove the heat generated by energy losses. If the heat has to escape through the electrodes, there is a maximum voltage which the dielectric can withstand, however thick.

With industrial insulation, discharges in holes or weak spots or over the surface often cause breakdown.

At lower voltages, breakdown frequently comes from chemical deterioration during irreversible electro-chemical actions.

(5) Long-chain molecules can provide fibrous, flexible and tough materials. Low creep and rigidity come with cross-linking—a polar crystal is a limiting case. Plastics are essentially heterogeneous; even when mainly crystalline, these regions must statistically be connected by amorphous regions.

In exemplifying these principles, reference was made to the long-chain hydrocarbons, like polythene and polystyrene, which fulfil expectations in having loss angles of merely 1–3 or 4×10^{-4} up to 10^{10} c./s. and can be processed. The substitution of hydrogen by fluorine yields P.T.F.E., which can be used up to 300° C., with low losses, and is much harder. By replacing a fluorine atom by chlorine, the material P.C.T.F.E. can still be used up to 200–250° C., can be transparent and flexible or translucent or more rigid, but the molecule is now asymmetrical so the loss angle is much higher. Hardening by cross-linking can be achieved with polythene by neutron bombardment in an atomic pile. Experience is scanty but this discovery is of the highest interest, because at present cross-linking is usually achieved chemically, as probably in the epoxy resins; and, although hard and adhesive materials result, they have rather high losses through asymmetry and, being built from carbon, hydrogen and oxygen, are limited in temperature. In the silicones the carbon–carbon link is replaced by the silicon–oxygen link, which fortunately seems to have so short a relaxation time that the loss angle is low except at the highest frequencies, and the advantages are gained of high-temperature operation, resistance to moisture and to discharges.

Many other examples were considered, and it was deduced that to cover all uses recourse is still necessary to the engineering methods of combining fibres such as paper, nylon, 'Terylene' and glass with impregnants such as amino-, epoxy and silicone resins on the pattern of reinforced concrete.

The miscalled ferroelectrics have many dielectric analogies with ferromagnetism, such as high and variable permeability, domains, electrostriction and a Curie point in an order–disorder transformation; but they arise from a rather accidental structure delicately poised between ionic and homopolar bonding. Furthermore, there are the anti-ferroelectrics where the low-temperature dipole moments may be oppositely oriented to cause a low polarization in this region.

The theory of electronic breakdown has had outstanding success in calculating the intrinsic electric

strength from structural parameters to give agreement within experimental variation; but the range is rather restricted—from 4 to 15 MV./cm.—so that there is more practical interest in raising the working and test stresses of insulation nearer the intrinsic electric strength, whatever it may be. One of the most important developments has been in the theory of internal discharges. The accompanying practical development has lain in decreasing the number and size of voids and by increasing their electric strength by fluid pressure. In good capacitors and, more notably, in the thick insulation of the high-voltage pressure-type cable, transient stresses have been withstood approaching one-half the intrinsic electric strength. Since the discharges are repeated every cycle, the development of cables and other gear which work at quite high radio-frequency electric stresses is extremely creditable.

Practical success in a very thin dielectric, which would have essentially a high electric strength, has been elusive; but an oxide film shown at the meeting gives some hope.

Low-voltage apparatus fails most often by electrochemical deterioration, and great ingenuity has been shown in the chemical–physical field in solving this problem. An example was given of a nascent-hydrogen acceptor which prolongs the life of certain insulation five- to thirty-fold.

During the meeting, Dr. B. Szigeti, of the University of Liverpool, indicated that although Fröhlich's theories gave the conditions for breakdown and very often permitted the successful calculation of the electronic electric strength, there is a great deal more to examine in the detailed mechanism. The theoretical physicists would secure great help from accurate information of time-lags in breakdown and the growth of pre-breakdown currents. The experimentalists, however, find extreme difficulty both in the measurements and in defining what they are measuring. Dr. Whitehead had already mentioned that, in certain connexions, whether Fröhlich's 'amorphous' or 'crystalline' theory applies is determined by the presence or absence of dipoles rather than the degree of crystallinity.

Dr. Whitehead defended the protracted consideration which engineers often have to give to projects strongly favoured by scientific argument, owing to the many associated problems which have to be solved and the grave consequences of error. Prof. A. M. Tyndall wound up the meeting in expressing his satisfaction that studies in theoretical physics (begun in his department at Bristol) had contributed so fruitfully to engineering practice and progress.

FERTILIZER RESPONSES IN EAST AFRICA

By Dr. D. W. DUTHIE

East African Agriculture and Forestry Research Organization, Kikuyu, Kenya

PRIOR to 1939, field-trials had proved the value of phosphates on wheat in the Kenya Highlands, but there appeared to be little prospect of chemical fertilizers finding a place in African farming. After the War, however, it became clear that food production in East Africa could not keep pace with the rapidly increasing population, and funds were provided, from local sources as well as from the Colonial Development and Welfare Scheme, to extend the field and laboratory studies of fertilizer response on African as well as European farms. Existing knowledge and experience were collected at a conference in 1949[1] at which preliminary results of the new experiment schemes were reported. In February 1953 a second conference was held at the headquarters of the East African Agriculture and Forestry Research Organization, Muguga, Kenya, to discuss the work of the previous three years and to review the present position. This meeting was under the chairmanship of Sir Bernard Keen, director of the Organization, and included members of the research staff of his Organization as well as specialist officers from the Departments of Agriculture of Kenya, Tanganyika, Uganda and Zanzibar, and from the Empire Cotton Growing Corporation, the Overseas Food Corporation, the Tea Research Institute of East Africa, and African Explosives and Chemical Industries, Ltd. Dr. E. M. Crowther, deputy director of Rothamsted Experimental Station, and Prof. M. Stelly, of the Agricultural College, University of Georgia, United States, attended the meeting by invitation.

A great deal of attention was focused on the effects of phosphatic fertilizers on food crops, since the exploitation of a deposit of primary phosphate (francolite) at Tororo in Uganda is now being carried out on a commercial scale. It is clear that the raw Uganda rock phosphate is not suitable for application as a fertilizer if immediate responses are required; but it shows residual effects which may be of importance in indirect manuring of crops by fertilizing grass leys in the rotation. During the War a modification of the Rhenania process was developed in which the rock phosphate was calcined with crude sodium carbonate from Lake Magadi in Kenya; the resulting product—usually called sodaphosphate—contains a high proportion of citric-soluble phosphate averaging 18 per cent out of a total phosphate content of about 21 per cent. In pot culture experiments the phosphate in sodaphosphate was almost as effective as the superphosphates, but in field-experiments considerable variation was obtained in comparative responses. One group of field-trials showed sodaphosphate to be about 5 per cent less effective than superphosphate, while in another group it was little more than half as effective, both comparisons being made on equivalent dressings of citric-soluble phosphate. Improved methods of manufacture, possibly with concentration of the raw material before processing, may increase the effectiveness of sodaphosphate and reduce the size of dressing required.

It appears that the more acid, leached, highly coloured soils give responses to phosphate, whereas the pallid soils do not normally react so well. This generalization is by no means straightforward, since other factors, as yet unexplained, may affect the response. For example, at least one area was noticed in Kenya in which something prevented the higher yield which was indicated by observation of the crop in its earlier stages, and it has been suggested that deficiency of zinc or copper may possibly be a factor in phosphate responses in some parts of East Africa.

Of the crops studied, wheat seems to give the most clear-cut responses to phosphate, 500 lb. sodaphosphate or 160 lb. double superphosphate per acre being the recommended dressings where phosphate is required. Among other food crops, sorghum responds better than maize, and maize better than finger

millet; sweet potatoes have given very little response. In Zanzibar, applications of phosphate to pine-apples did not give positive responses, and even tended to decrease yield, but on one soil type (*changa*) as much as 100 per cent increase in the yield of maize, and nearly 300 per cent increase in sunflower yield, were obtained from 2 cwt. single superphosphate per acre, while 3 cwt. caused a 200 per cent increase with rice. In field trials carried out by the Overseas Food Corporation, groundnuts responded to phosphate in all areas, the average increase in yield being about 100 lb. kernels per acre with a dressing of 0·5 cwt. phosphate; some evidence was obtained that half this dressing would be nearly as effective. In sisal trials, phosphate has not so far caused increases in yield of fibre, but experiments have recently been planted on exhausted land, and the results of these may reopen the question. There is some evidence that phosphate reduces chlorotic mottling, and on certain soil types it is useful in establishing young sisal. With pyrethrum, 300 lb. per acre double superphosphate, placed at the base of the ridge before planting, gave striking responses in the Southern Highlands of Tanganyika; but in Kenya the effect of phosphate applied in the planting holes was to cause a short-lived increase in flower production during the first season only. Coffee did not respond to added phosphate by giving increased yields, although evidence was obtained that the plants had taken up additional phosphate.

The method of application of phosphate is particularly important in East Africa, and with grain crops it seems to be essential to place phosphate below the seed or to drill it in with the seed; when it is broadcast or applied between the rows it stimulates the growth of weeds, which may smother the crop plants before their roots can reach the fertilizer.

At Muguga, laboratory work on the chemical aspects of phosphate manuring has shown that, although fractionation of the soil phosphate into 'acid-soluble' and 'adsorbed', by the method of Bray and Kurtz, provided some relationship with field response to phosphate, the percentage saturation of the base exchange capacity of a soil could give a better forecast of its reaction to applications of phosphatic fertilizers. Recently, a relationship has been found between the citric-soluble silica in the soil and the effect of added phosphate; but the meaning of this is not yet clear.

Physiological studies at Muguga of the mineral nutrition of maize and sorghum demonstrated a marked interaction between nitrogen and phosphorus. A state of balance between nitrogen and phosphorus can be established at many different levels of supply, but of course the highest suitable level produces the largest plant. Field experiments by the Overseas Food Corporation confirmed these laboratory results, since with both maize and groundnuts nitrogen and phosphate together gave much better responses than either alone. Fertilizer trials carried out by the East African Agriculture and Forestry Research Organization in African areas showed that, with maize, sorghum and millet, the effect of added nitrogen was greater on pallid soils, on which phosphate gave little response, as compared with highly coloured soils which responded definitely to phosphate.

In field-trials in the European Highlands of Kenya, laid down jointly by the Department of Agriculture and African Explosives and Chemical Industries, it was found that the application of nitrogen to maize at tasseling had a consistently beneficial effect, and it is suggested that ½–1 cwt. sulphate of ammonia both at planting and at tasseling would be an economical dressing on many soils. The Uganda Department of Agriculture reports striking responses by maize to sulphate of ammonia, one field-trial giving 66 per cent increase with 2 cwt. per acre, while 4 cwt. gave 97 per cent increase; in another experiment where the control yield of maize was 3,400 lb. per acre, a 50 per cent increase was caused by 2 cwt. sulphate of ammonia. In Zanzibar most soils respond to nitrogen, increases in maize yield as high as 80 per cent being given by 1 cwt. sulphate of ammonia per acre. Sorghum has also given marked responses in Zanzibar, a 50 per cent increase with 1 cwt. and 200 per cent increase with 3 cwt. sulphate of ammonia being on record; rice has given even greater responses, one experiment on Pemba Island giving a five-fold increase due to sulphate of ammonia.

In the Kenya Highlands, wheat did not give worthwhile increases in yield with sulphate of ammonia, but it seems possible that some other factor is limiting growth and yield, and this requires further investigation. Pine-apples in Zanzibar gave good responses to nitrogen, both the number and the size of fruit being increased during the first two seasons. In Uganda cotton benefited from the application of 2 cwt. sulphate of ammonia at flowering, but the increase in yield was not economic. In that area the action of nitrogenous fertilizers is obscured by a build-up of soil nitrate during fallow or resting periods, and investigations are now being carried out on the nitrogen cycle in the soil. In the Lake Province of Tanganyika, where cotton is rotated with bulrush millet, a top dressing of nitrogen following organic manuring raised the yield in the year of application only, but an increase of this kind would not attract African peasant farmers, since the risk of crop failure through drought and other causes would make them hesitate to put actual cash into the crop.

In both Kenya and Tanganyika, pyrethrum gave uneconomic responses to nitrogen, and in several trials it delayed flowering or decreased the final yield significantly. With sisal, too, economic increases in the yield of fibre have not resulted from applications of nitrogen, although growth records have indicated that nitrogen hastens the growth of the plant. Experiments by the pasture research section of the Kenya Department of Agriculture have shown that sulphate of ammonia increases the yield and the feeding value of both grass leys and established pastures, but in these trials a surprisingly rapid and definite increase in soil acidity was found when the heavier dressings of sulphate of ammonia were applied. Methods of extending the growing season, and of preserving grass and other bulk feeds, are being tested, since increases in grass production only during the normal season would accentuate the lack of feed during the rest of the year.

In most parts of East Africa no significant responses to potash were obtained with maize, sorghum and millet; but on the coastal belt of Tanganyika there were important potash effects on maize and sorghum in the second and third seasons. On one of the Zanzibar soil types (*kinongo*) potash has occasionally given excellent responses with maize and sorghum, and there is strong evidence that potash assists cereals to grow away from borer attack. Significant responses to potash on wheat are recorded from the Southern Highlands of Tanganyika, and potash

combined with phosphate gave marked increases in yield, but the cost of treatment is high (£5–8 per acre) owing to the long road haul from the nearest railhead, and the expenditure may not be worth while in view of the risks of crop failure. In Kenya, small significant increases in yield of wheat were caused by potash in one year, but in the two following years the response was negligible, and it is possible that this transitory effect was due to the particular seasonal conditions in the first year. Even when no yield increases were obtained, the grain from the potash plots was noticeably plumper than that from other treatments.

Both in Kenya and Tanganyika, potash had no definite effects on the yield of pyrethrum flowers; it was thought at one time that lack of potash might be connected with the incidence of Ramularia bud disease, but no conclusions on this point can yet be drawn. Tobacco experiments in the Southern Highlands of Tanganyika showed increases in yield which were directly dependent on the amount of potash applied, and the highest yields were given by a balanced NPK mixture which produced more than 78 per cent of high-grade leaf. Coffee gives no response to potash in East Africa, and on the whole most tea soils are well supplied with potash, but the tea crop drains the potash reserves, since the K_2O content of the tea 'flush' may be as high as 2·5 per cent.

Healthy sisal in Tanganyika does not seem to respond to potash, and it has been noticed that excess potash results in acute chlorotic mottling even if lime and phosphate are adequate. This is curious in view of the fact that banding disease, which is prevalent in parts of Tanganyika, is primarily due to potash deficiency, and several estates are now applying potash as a routine. It has been suggested that the soil K/N ratio is important in controlling the uptake of potassium by plants, and that a K/N ratio of 0·05 is critical.

Applications of lime have given increases in yield in a few field trials, but on the whole liming has not given responses in East Africa with wheat, maize, sorghum, groundnuts, pyrethrum or coffee. There is some evidence that Kenya soils are not likely to react to lime when they are less acid than *p*H 5·2, but above this acidity there is no certainty that liming will be beneficial. Sisal is a gross calcium feeder, and continuous sisal growing on red earths leads to progressive acidification of the soil. Chlorotic mottling of sisal is reduced by applications of limestone, and it seems possible that this disease is related to excessive uptake of minor elements; excessive cobalt has been reported in leaves showing chlorotic mottling. It is sometimes stated that sisal plants grown on soil which is low in calcium tend to be more susceptible to bole rot; but a definite association between the two has not yet been confirmed.

With organic manures, the most striking results were obtained on hill sands in the Lake Province of Tanganyika, where the residual effects of cattle manure at 3 or 7 tons per acre have persisted for eight years on cotton rotated with bulrush millet. Equivalent amounts of nitrogen and phosphate gave results similar to, or greater than, these organic dressings, but only in the year of application. Cattle manure is particularly effective on the highly leached soils of the thinly populated upper Kikuyu bracken lands in Kenya, where applications of the major fertilizers are not very effective. In addition to these striking and as yet unexplained effects of organic manures, there appears to be an overall response to cattle manure and compost on most food crops in most areas of East Africa. The fact that cattle manure is not widely used by African farmers is probably explained by the labour involved in transport and application, and it may be the comparative lack of wheeled transport that is the underlying cause of this reluctance to return plant and animal residues to the soil.

With coffee, mulching has proved to be much more effective than compost or cattle manure, both in Kenya and in Tanganyika. From studies of the soil moisture relationships it has been shown that the effect of mulching is far greater in assisting the penetration of rain than in impeding evaporation during the dry season. Thus coffee planters are advised to apply mulch at the onset of the rainy season, field trials having shown that the yield in a dry year could be increased by 100 per cent, while a 75 per cent increase may be obtained in a year of normal rainfall.

The microbiological aspects of the nitrogen cycle in soil are being studied at Muguga, since it has been recorded by the Uganda Department of Agriculture that large amounts of nitrate (up to 300 p.p.m.) can accumulate in the top inch of bare fallow soil, with a sharp drop to 50 p.p.m. in the second inch and a rise to 300 p.p.m. at a depth of about 3 feet. In shaded or mulched soil only very small amounts of nitrate are found (less than 10 p.p.m. in the top six inches), while cropped soils show varying amounts, less than bare fallow but more than shaded soils. The basic explanation of these field-results is not yet complete, since they do not fit into the usual pattern of microbiological action, and further work, in both field and laboratory, is being carried out.

For some years deficiencies and excesses of minor elements, in both crops and stock, have been suspected in East Africa, but it is only recently that facilities for spectrographic estimation of these has been made available. Zinc deficiency may be involved in phosphate response, copper deficiency in coffee has been indicated by growth responses to fungicidal sprays containing copper, excess cobalt has been reported in sisal leaves showing chlorotic mottling, and some evidence of calcium deficiency caused by excessive uptake of manganese has been found in coffee in Tanganyika. A recent observation by the Fisheries Research Organization that the waters of Lake Victoria are abnormally low in sulphur points to the need for study of this element in the crops and soils of the vast drainage basin of that lake.

[1] *E. Afr. Agric. J.*, **15**, 61 (1949).

TENTH INTERNATIONAL PHYTOGEOGRAPHICAL EXCURSION

THE International Phytogeographical Excursion held in Spain this year was the tenth of the series which began in the British Isles in 1911; it consisted of two parts, the first starting from Barcelona on June 25 and ending at Madrid on July 15, and the second beginning at Madrid on July 16 and returning there on July 22. Twenty-six visiting botanists of twelve different nationalities took part, some for both parts of the excursion, some for only one, in addition to Profs. Don Salvador Rivas-Goday and Don Fernández-Galiano, who led

the party, and other Spanish botanists who accompanied it for varying periods in the districts of which they had special knowledge. Dr. Werner Lüdi, the well-known Swiss phytogeographer and chairman of the international committee responsible for organizing the excursions, was the director on this occasion. Like its predecessors, the excursion in Spain was both scientifically profitable and enjoyable. Much ground was covered, as the route extended from Barcelona in the north-east to Lugo in the north-west and the Sierra Nevada in the south, so inevitably there was little time for intensive study of any one locality or of the numerous and fascinating ecological and phytogeographical problems which arose at every step. Nevertheless, all who took part in the excursion felt that they had enjoyed an incomparable opportunity of seeing a number of representative and very diverse regions of a country which has perhaps no equal in Europe as a field for ecological study.

The party travelled in a diesel motor-coach, large enough to accommodate them all, together with a technical assistant and the baggage, and the skill with which the drivers of this somewhat cumbrous vehicle negotiated narrow and difficult mountain roads was quite remarkable. This method of travel not only allowed the maximum freedom in the choice of route but also allowed stops to be made for photography or note-taking wherever the vegetation seemed particularly interesting.

The first area studied was the curious rocky ridge of Montserrat, which made an excellent introduction to the rich flora of the coastal region of Catalonia with relatively luxuriant maquis vegetation depending on mild winters and not excessively dry summers. From there, travelling via Lérida to Saragossa, the party crossed the arid region of los Monegros in Aragon, where a rainfall of less than 300 mm., combined with cold winters, very hot summers and a porous gravelly soil (derived from alluvial beds of Oligocene age), gives rise to a very scanty covering of vegetation. Xerophytes such as *Capparis spinosa*, *Peganum harmala* and *Lygeum spartum* are common; but though the vegetation has the appearance of a very dry steppe, almost of a semi-desert, occasional relics of *Quercus ilex*, *Pinus halepensis* and *Juniperus thurifera* show that the climax is woodland and that the Spanish botanists are right in terming it a 'pseudo-steppe'. The potentially most fertile land in this dry region lies, of course, in the moister hollows and river valleys, but cultivation is often prevented or impeded by high concentrations of gypsum and other salts. Many of the damp hollows are still occupied by a natural vegetation of halophytes such as *Salicornia* sp., *Suæda fruticosa* var. *brevifolia*, etc., but where irrigation water is available rice is successfully cultivated.

After a brief visit to the central Pyrenees, including the impressive National Park of Ordesa, the excursion continued north-westwards to Pamplona and then via Logroño and Soria to Burgos. The journey along the southern foothills of the Pyrenees was an interesting demonstration of the gradual change in the vegetation from the dry continental conditions of Aragon to the moister and more Atlantic conditions of Navarre. Atlantic plants such as *Erica vagans* and many of the common British wayside species gradually increased in abundance, and near Pamplona meadows of true sward-forming grasses at low altitudes were seen for the first time. Evidence of a still more markedly Atlantic climate was seen in the highlands of the Macizo Ibérica between Logroño and Soria, where at altitudes above 1,000 m. there are extensive heaths of *Calluna*, *Erica aragonensis*, etc., reminiscent of the moorlands of Ireland and Scotland. Some characteristically 'British' plant communities, such as a 'wet heath' with *Nardus*, *Juncus squarrosus*, *Sphagnum* spp., etc., were met with here.

After Burgos the route, before turning south-east towards León and Castile, passed through the Cantabrian mountains to the Asturias and Galicia, the region of Spain with the most strongly developed oceanic climate and vegetation. The luxuriant roadside vegetation of the Asturias with its abundance of *Daboecia*, species of *Erica* and, in places, of *Osmunda*, recalled Cornwall and south-west Ireland, though the fields of maize and the vines around the houses testified to higher summer temperatures. It was interesting to see, in the Asturias, enclosed fields and hedgerows similar to those of England, as well as a *Quercus petraea* woodland association floristically very similar to that in Great Britain. The change from the Atlantic conditions of Galicia to the relatively dry and continental climate of León and the still drier climate of north-western Castile was sudden and very striking, though it was interesting to note that familiar British plants such as *Juncus* spp. persisted in edaphically moist habitats.

From Madrid the Sierra de Guadarrama, with its interesting endemic montane flora, was visited, and then in the second part of the excursion the route turned south across the monotonous and intensively cultivated plains of La Mancha towards Andalusia. The gorge of Despeñaperros in the Sierra Morena which forms the frontier between Castile and Andalusia showed a striking change in the flora, and various southern species were seen for the first time. In the Guadalquivir valley near Córdoba the extensive fields of cotton were a remarkable sight for northern European botanists. The most memorable day on the second part of the excursion was the visit to the Sierra Nevada and the ascent of the Picacho de Veleta (3,470 m.), which is readily accessible by a road almost reaching the summit. The beautiful and varied alpine flora at altitudes above 2,500 m., with its abundance of rosette plants and small spiny shrubs, seemed very strange to most members of the party, and very few of the species were familiar to those who had not visited the area before; one member of the party said that botanizing here was like "botanizing on the moon".

To an English botanist the foremost impression of this rapid survey of the flora and vegetation of Spain was of the immense wealth of species and the high degree of endemism. Travelling as we did, rapidly from place to place, the flora seemed to be inexhaustible and changed every day, even when the climatic and other conditions seemed to be similar. Everywhere endemic species, restricted to the Iberian Peninsula, or to some part of it, appeared to play a prominent part in nearly all the plant communities.

Another vivid impression was of the universal ecological importance of soil conditions. In all climatic regions of Spain, both dry and wet, and at all altitudes, there was a marked contrast between the flora of calcareous and non-calcareous soils, and no evidence was seen supporting the view that edaphic factors are less important in Continental countries than they are in the British Isles. Though the distinction of the calcicole and calcifuge floras was always apparent, the soil preferences of individual species were not always the same as in Britain. Thus

Rhamnus catharticus, regarded in Britain as a typical calcicole, grows in the Sierra de Guadarrama on poor acid soils, and what a British botanist would regard as strange mixtures of calcifuge and calciole species were sometimes encountered.

It was of great interest to see the ecological range of some of our British plants in climates very different from our own. Some British species appeared to be extremely versatile, and one gained a new respect for the capabilities of such plants as *Jasione montana* when seeing them growing with Mediterranean xerophytes such as *Dorycnium suffruticosum* and *Halimium umbellatum*. In Soria province it was odd to see *Arctostaphylos uva-ursi*, regarded by British botanists as a typically northern plant, growing in pinewoods at no great altitude in company with typically Mediterranean shrubs such as *Erica arborea* and *Lavandula stoechas*.

It was not surprising to find that in the arid regions of Spain some plants which in Britain are confined to dry habitats require moist soil conditions; thus *Blackstonia perfoliata*, which in Britain grows in relatively dry habitats, in the arid climate of los Monegros is restricted to damp places.

The excursion gave its members not only a unique opportunity of studying the natural and semi-natural plant communities of Spain, but also many fascinating glimpses of agricultural practices and the way in which these varied in the different regions. Many members were particularly interested in the peculiar system of shifting cultivation on the poor hill soils in Galicia where a long fallow stage of the tall leguminous shrub *Sarothamnus welwitschii* often intervenes between periods of cultivation of cereals and other crops. The *Sarothamnus* is cut for litter, and its seeds are sown with those of the cereal crop.

It is a pleasure to mention the generous hospitality which the members of the excursion everywhere received. Not only were the two leaders of the party, Profs. Rivas-Goday and Galiano, of the Faculty of Pharmacy, University of Madrid, unsparing in their efforts to help their foreign guests and answer their many questions, but also, in all the larger towns visited, hospitality was offered on a most generous scale. Since in Spain botany is generally linked with pharmacy, it was usually the local associations of pharmacists (Colegios de Farmacéuticos) to which the excursion was indebted for this hospitality, which not only included splendid banquets and official visits to places of scientific or artistic interest, but also such delightful features as displays of traditional dancing in Córdoba, Oviedo and Saragossa. The warmth of this welcome as well as the beauty and interest of the landscapes and the plants will make the Tenth International Phytogeographical Excursion live long in the memories of those who took part in it.

P. W. Richards

NEWS and VIEWS

Architectural Science at Sydney: Dr. H. J. Cowan

Dr. H. J. Cowan, lecturer in civil engineering in the University of Sheffield, is shortly to take up his appointment to the newly created chair of architectural science in the University of Sydney. Born in 1919, he graduated with first-class honours in the University of Manchester in 1939, obtaining his master's degree a year later. From 1940 Dr. Cowan served in the Royal Engineers until he was wounded in Holland in 1945. After gaining experience with firms of civil engineering contractors and structural designers, he joined the teaching staff of University College, Cardiff, where he remained until he went to his present post in 1948. Since going to Sheffield, Dr. Cowan has carried out researches in reinforced and prestressed concrete and has published a number of papers and articles on these subjects in Britain and in the United States. His work on reinforced and prestressed concrete in combined bending and torsion is a noteworthy contribution in a new field of investigation, and for a thesis embodying some of this work he was awarded the Ph.D. degree. Dr. Cowan has taught structural engineering to students of architecture for the past five years, and he has delivered courses of public lectures on the theory of prestressed concrete design and on the design of concrete for ultimate strength.

British Occupational Hygiene Society

The British Occupational Hygiene Society has recently been formed and will hold its first conference at the London School of Hygiene and Tropical Medicine on November 2. Proceedings will be opened by the Minister of Labour, Sir Walter Monckton, at 11 a.m.; Dr. T. Bedford will then deliver his presidential address. During the afternoon the following papers will be read and discussed: "Measuring the Worker's Environment", by S. A. Roach, "The Problems of Chemical Toxicity", by D. G. Harvey, and "Occupational Hygiene and the Industrial Designer", by J. E. Braham. The Society hopes to promote knowledge of all matters which have a bearing on the health of men and women at their daily work. Regular conferences will be held at which both general problems and special technical aspects of occupational hygiene will be discussed. Particulars are available from the honorary secretary, Mr. P. C. G. Isaac, Public Health Engineering Laboratory, King's College, Newcastle upon Tyne, 1.

National Smoke Abatement Society: Annual Conference in Glasgow

The twentieth annual conference of the National Smoke Abatement Society will be held in the Banqueting Hall, City Chambers, Glasgow, during September 30–October 3, and will be attended by some four hundred and fifty members and delegates, drawn mainly from local authorities, government departments and the fuel and power industries. On the first day the president of the conference, Prof. F. E. Tylecote, emeritus professor of medicine in the University of Manchester, will give his address, which will be on smoke and the local authority. This will be followed in the afternoon by the Des Voeux Memorial Lecture, which will be given by Sir John Charles, chief medical officer, Ministry of Health, who will speak on air pollution in relation to preventive medicine. The sessions for the remaining two days will deal with the following subjects (with the speakers shown in brackets): the London fog disaster of December 1952 (Dr. J. A. Scott, Dr. A. Parker and Arnold Marsh); report on smokeless zones (Dr. T. M. Clayton); production and use of solid smokeless fuels (Dr. F. J. Eaton, G. E. Hall

and Islwyn Jacob); availability of solid smokeless fuels (J. O. Cooke, H. H. Prosser, Eric J. David and Commander C. Buist); and the efficient and smokeless combustion of fuel oils (K. H. Sambrook). The formal sessions of the conference will end with the annual general meeting of the Society, after which there will be an afternoon tour of the Loch Sloy power station and dams. Further information can be obtained from the Society at Chandos House, Buckingham Gate, Westminster, London, S.W.1.

Colonial Development Corporation: Statement of Accounts for 1952

THE annual report of the Colonial Development Corporation and statement of accounts for the year ended December 31, 1952 (No. 158; pp. 62; London: H.M.S.O., 1953; 3*s.* 6*d.* net), records that the expectation that 1951 would constitute the peak of loss has not proved correct: in spite of Lord Reith's drastic pruning, £638,747 was lost in trading compared with £643,404 the previous year, the consolidated operating loss being £1,097,091 as against £1,070,043. With losses on realization of assets of abandoned projects, the total Corporation deficiency of £3,805,208 (compared with £2,905,290 in 1951) brings the cumulative deficiency to £8,399,807. It is now emphasized that, in long-term development, while failures must be expected to show up first, successes often mature slowly and ten to fifteen years may be required before preliminary troubles are overcome, full production reached and a profit shown. Some projects are treated as passing from the development stage to the trading stage at a point when initial trading losses must be expected. Another eight projects were abandoned during the year, the largest being the Gambia Rice Farm; and, of nine new projects, five are merely investigations and the others are loans involving no field-work by the Corporation. The Corporation has no accumulated fund to absorb trading losses, and it is proposed that in future new projects will only be taken up on a strictly commercial basis. This is likely to exclude some types of desirable development such as agricultural settlement schemes; but, while it is recognized that application of a commercial criterion to the Corporation's general funds is salutary, the suggestion is made that the Corporation should be allowed to finance some projects which are socially valuable but are unlikely to be profitable, and that these investments should be recorded separately in its accounts and their results judged on other than a profit basis. Between December 31, 1951, and March 1, 1953, senior staff in the United Kingdom was reduced by 33 per cent and junior staff by 19 per cent. Of the United Kingdom staff of 248 on December 31, 1952, 80 were executive. Of the overseas staff of 19,000, 3,900 were executive: agricultural projects claimed 8,450; animal products, 1,000; factories, 1,100; fisheries, 150; forestry, 4,200; minerals, 2,000; and construction, 1,600.

Aeronautical Research in Academic Institutions

THE February issue of the *Aeronautical Quarterly* (4, Part 2; 1953) is an unusual number in that all but one of the contributions are from colleges or universities, and it is therefore interesting to gain from the contents an indication of the nature of the aeronautical research which is pursued in academic circles. The paper by A. Powell on the noise emanating from a two-dimensional jet above the critical pressure is a report on one part of the fundamental research being conducted at the University of Southampton into the nature—and amelioration—of jet noise; the physics of some oscillatory phenomena is being carefully investigated. Some of G. E. Gadd's work as Beit Scientific Research Fellow at the Imperial College of Science and Technology, London, is described under the heading of some aspects of laminar boundary-layer separation in compressible flow with no heat transfer to the wall; an analysis has been made which suggests that, with the types of pressure distribution most usual in practice and free stream Mach numbers up to 10, no serious errors would be introduced into the calculation of the separation-point of a laminar boundary layer by the assumption of the value unity for the Prandtl number and also for the index of the variation of viscosity with absolute temperature. The Department of Aeronautical Engineering in the University of Sydney is represented by a paper from Dr. W. H. Wittrick on the buckling of oblique plates with clamped edges under uniform compression; this is a piece of theoretical work, the need for which has come about with the introduction of swept-back wings. F. G. Irving's paper on the theory of the constant-area mixing of compressible flows as applied to high-speed wind-tunnel design contains a theory which was derived during the design by the author of the supersonic wind tunnel at the Imperial College, London, and the theory checks well with experiment in this tunnel and in one of the tunnels at the National Physical Laboratory, Teddington. Dr. Bryan Thwaites, of Winchester College, who earlier had contributed a rapid method of designing a ducted fan for a given performance, has a note on the performance of ducted fans in which is given the extension to the inverse problem of determining the flow past a given fan in conditions other than those of the design; the method is again rapid. K. E. G. Wieghardt, formerly of the Admiralty Research Laboratory and now of the University of Hamburg, suggests a useful parameter in the presentation of the many experimental results of the resistance of screens in a paper of that title. The *Aeronautical Quarterly* will now appear at six-monthly intervals. This may well be a sign of the times, since much of the expanding volume of aeronautical research is of a confidential nature.

Research Fellowships in the United States for Young European Scientific Workers

IN response to a request from the Organization for European Economic Co-operation, the United States Government, through its Foreign Operations Administration, has provided funds of more than a million dollars to enable a hundred and fifty outstanding young scientific workers from Europe to travel to and live in the United States for up to two years in order to study and gain experience in American research institutions. By this means it is hoped to advance scientific research and to facilitate the adoption of the results of scientific research in production techniques. The funds are available in the first instance until the end of 1955, and the scheme is being administered by the National Academy of Sciences, Washington, D.C. Successful candidates, who will be required to undertake to return to their own countries and resume their scientific work there on completion of tenure of fellowships, will, for the most part, participate with their American colleagues in the current fundamental scientific research programme at the particular

institution; but opportunities may also be provided towards the end of the tenure of the fellowship for work on problems in industrial or other laboratories in applied research related to the fundamental research they have previously carried out. For the United Kingdom about twenty-five fellowships will be available, and the selection will be made by the Royal Society. No age-limits are specified, but it is expected that most of the fellowships will be awarded to persons about 26–32 years of age. Candidates who propose to do research in the natural sciences and in the engineering, agricultural and medical sciences, but excluding clinical medicine, will be considered; they must have a doctorate in science or the equivalent experience. Applications, which may be made at any time, will be considered at regular intervals; for the first two sets of applications the closing dates are, respectively, October 1 and November 30. Application forms and further information can be obtained from the Assistant Secretary, Royal Society, Burlington House, London, W.1.

In recognition of the contribution to Anglo-American understanding made by King George VI, the English-Speaking Union of the United States has established memorial fellowships to enable British men and women (aged 17–29 years) to continue their scientific and technical education in the United States. Twenty-five fellowships have been established for the academic year 1954–55, and each is valued at 2,500 dollars. Further information can be obtained from Mrs. D. R. Dalton, King George VI Memorial Fellowships Committee, English-Speaking Union, 37, Charles Street, London, W.1.

Mammoth Hunters in Austria

The sixth volume of the *Mitteilungen der Prähistorischen Kommission der Österreichischen Akademie der Wissenschaften*, published in Vienna, 1952–1953, includes a long article on a group of prehistoric home sites containing a quantity of mammoth bones and stone implements which were investigated some little while ago by the late Drs. J. Bayer and H. Obermaier. The sites are near Langmannersdorf on the Perschling in the region of St. Polten. The implements recall those found at a somewhat similar mammoth-hunter site at Unter Wisternitz in Moravia, some miles from Brno. The fauna comprises bones of wolf, fox, mammoth and some small rodents, as well as those of hare and rhinoceros. The stone industries are of the late Aurignacian (late Gravettian) type normal for the region. They are well illustrated in fifteen full-page drawings. There are also some half-tone illustrations of the sections cut and some of the finds of bones. A detailed inventory of the objects unearthed concludes the paper.

Mutual Inhibitory Effects in Nodule Formation

P. S. Nutman has shown that the number of root nodules formed on clover, in test-tube culture on agar, depends directly upon the volume of the medium and inversely upon the number of seedlings present per unit volume of medium (*Ann. Bot.*, N.S., **17**, 65, 95; 1953). Plants which form nodules early in seedling development inhibit nodule formation on an associated plant more strongly than plants which normally form nodules later. Among all the types of plants examined, for example sparsely or abundantly nodulating plants, the mutual inhibiting effects when grown in pairs were found to be the same, notwithstanding large differences in plant size. Similar inhibitory effects were observed in the presence of non-leguminous plants; for example, lettuce and flax reduced nodulation on clover plants but to a lesser extent than companion clover plants. Comparable results were obtained in experiments with lucerne and vetch. These and other interesting observations are fully described and discussed. The hypothesis is advanced that bacterial infection and nodule formation may be inhibited by specific root secretions.

National Institute of Agricultural Botany, Cambridge

Vol. 6 of the *Journal of the National Institute of Agricultural Botany* contains, besides various technical papers and results of its cereal and brussels sprouts trials, a full report of the Institute's first crop conference held last December. On this occasion the suitability of different varieties of wheat, fodder-beet and potatoes for growing in Great Britain was discussed, and much information that had been accumulated over a long period of years was brought together for the first time. The subject in each case was considered from a number of aspects, so that the farmer may judge for himself what type of crop may best suit his own set of conditions. The volume also includes the 1950–51 report of the Seed Production Committee and that of the 1952 Conference of Seed Analysts. In an appendix to the latter, a suggestion is made that expression of weed seed impurities by number per ounce rather than percentage by weight, as at present, would give a better indication of the value of a seed sample. Weed seed content also forms the subject of a detailed survey made by the Official Seed Testing Station of the samples submitted to it over a long term of years. The results show that, since 1923, definite changes in the impurities recorded have occurred. These seem to be largely associated with changes in the sources of supply of the crop seed and particularly with the greatly increased home production of grass and clover seed.

Spectrographic Study of the Double-lined Binary System *H.D.* 27483

A spectrographic study of the double-lined binary system *H.D.* 27483 has been made at the Dominion Astrophysical Observatory, Victoria, B.C., and Ruth J. Northcott and K. O. Wright have published the final results from plates taken at the Dominion Astrophysical Observatory, the David Dunlap Observatory and the Mount Wilson Observatory—a total of eighty-eight plates in all—for this system (*Contrib. Dom. Astrophys. Obs.*, Victoria, B.C., No. 25; 1952). The orbital elements have been determined, the final period being 3·05911 days and the eccentricity $0{\cdot}017 \pm 0{\cdot}006$ (incidentally, it is worth noticing that this is close to the eccentricity of the earth's orbit). The physical characteristics of the system show that the mass of the system is 0·97 that of the sun, the radius a of the orbit $3{\cdot}95 \times 10^6$ km., the inclination of the orbit 51°, the magnitude 6·86 and the absolute magnitude 4·0, the effective temperature 6,570° K. and the spectrum *F5*. These figures refer to the primary component and are nearly the same for the secondary component, the mass of which is 0·959 that of the primary and its absolute magnitude 4·1. While the data indicate that the system is quite normal, the luminosities, according to the Russell diagram, are lower than the average for the spectral type.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: W. J. Blackie (deputy director of agriculture, Fiji), director of agriculture, fisheries and forestry, Hong Kong; E. S. Capstick (senior agricultural officer, Trinidad), deputy director of agriculture (crop husbandry), Trinidad; R. C. Michaelides (agricultural superintendent, class *F*, Cyprus), agricultural officer, class II, Cyprus; B. G. Montserin (chief scientific officer, Trinidad), deputy director of agriculture (research), Trinidad; I. C. Papadopoulas (temporary agricultural superintendent, class I, Cyprus), agricultural officer, class II, Cyprus; E. J. Shrubshall (deputy director of forests, Federation of Malaya), director of forests, Federation of Malaya; W. K. M. Mitchell (agricultural officer, Jamaica), senior agricultural officer, Jamaica; D. R. Wilson (statistician, East African Statistical Department, East African High Commission), deputy government statistician, Nigeria; B. O. L. Duke, medical research officer, Grade III, Nigeria; G. W. Ivens, senior scientific officer (botanist), Colonial Insecticide Research Unit, Tanganyika; W. Wilkinson and R. M. C. Williams, scientific officers (entomologists), East African High Commission; A. W. Anderson, veterinary officer, Gambia; A. G. Warren, veterinary research officer, Nyasaland; G. Usher, plant pathologist, Gold Coast.

The Night Sky in October

NEW moon occurs on Oct. 8d. 00h. 40m., U.T., and full moon on Oct. 22d. 12h. 56m. The following conjunctions with the moon take place: Oct. 5d. 13h., Mars 5° N.; Oct. 5d. 15h., Venus 5° N.; Oct. 9d. 10h., Saturn 8° N.; Oct. 10d. 01h., Mercury 3° N.; Oct. 26d. 12h., Jupiter 3° S. In addition to these conjunctions with the moon, Mercury is in conjunction with Saturn on Oct. 4d. 01h., Mercury 3·5° S., and Venus is in conjunction with Mars on Oct. 4d. 06h., Venus 0·03° S. Mercury, an evening star, is too close to the sun for observation. Venus is a morning star, rising at 3h. 15m., 4h. and 4h. 45m. on October 1, 15 and 31, respectively. The stellar magnitude of the planet is −3·4, and the visible portion of the illuminated disk varies from 0·88 to 0·93. Mars, a morning star, rises about 3h. 20m. throughout October, moving from the constellation Leo into Virgo, and towards the end of the month it lies midway between β and η Virginis. Jupiter rises at 20h. 55m., 20h. 05m. and 19h. on October 1, 15 and 31, respectively, and is stationary on October 15, afterwards moving westward in the constellation Taurus. Saturn is too close to the sun for favourable observation and on October 23 is in conjunction with the sun. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Oct. 2d. 4h. 12·5m., θ Canc. (*R*); and Oct. 24d. 19h. 54·6m., 36 Taur. (*R*), *R* referring to reappearance. On October 1 the planet Uranus, magnitude 5·9, occulted by the moon, reappears at 4h. 20·0m. The Orionid meteors, active from about October 20 to October 23, will not be easily observed owing to moonlight.

Announcements

H.R.H. THE DUKE OF EDINBURGH has accepted honorary fellowship of the Royal Aeronautical Society. The following have also been made honorary fellows of the Society: Sir Geoffrey de Havilland, Sir Arthur Gouge and Lord Hives.

THE Lord President of the Council has appointed Mr. W. L. Heywood, general secretary of the National Union of Dyers, Bleachers and Textile Workers, and secretary of the National Association of Unions in Textile Trades, to be a member of the Advisory Council for Scientific and Industrial Research.

THE Italian Society of Geophysics and Meteorology is offering a scholarship of 300,000 lire for the academic year 1953–54, which is intended to enable a student to complete his studies in meteorology or geophysics and is tenable at either the Institute of Terrestrial Physics of the University of Naples or the Institute of Geophysics and Geodetics of the University of Genoa. Details of application, which should be made before October 15, and further information can be obtained from the Society at Via Balbi 5, Genova.

THE thirtieth meeting of the Australian and New Zealand Association for the Advancement of Science will be held in Canberra during January 13–20, 1954, under the presidency of Sir Theodore Rigg, director of the Cawthron Institute, Nelson, New Zealand. The hon. secretary for this meeting will be Dr. C. Barnard, Box 109, City, Canberra.

THE Physical Society's thirty-eighth Annual Exhibition of Scientific Instruments and Apparatus will be held during April 8–13, 1954, in the Physics and Chemistry Departments of the Imperial College of Science and Technology, South Kensington, London, S.W.7. Further information can be obtained from the Secretary-Editor of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

ARISING from the success of the short symposium on analytical chemistry held in Birmingham in 1952, the Midland Society for Analytical Chemistry will be holding a similar but larger symposium during August 25–September 1, 1954. Besides the presentation of original papers and discussions of recent advances in various analytical fields, there will be an exhibition of new and special apparatus, and visits to local places of interest will be organized. Further information can be obtained from the secretary of the symposium, Dr. J. W. Robinson, Post Office Engineering Department, Birmingham 9.

A CONFERENCE on "Field Studies in Urban Areas", suitable especially for teachers, will be held in the Anatomy Theatre, University College, Gower Street, London, W.C.1, on October 24. The conference is being organized by the Association of Agriculture and the Joint Biology Committee, the latter being made up of representatives of various teaching, biological and nursing bodies. The chairman of the conference will be Mr. F. H. C. Butler, director of the Council for the Promotion of Field Studies. Further information can be obtained from the Secretary, Joint Biology Committee, 11 Fillebrook Hall, Fillebrook Road, Leytonstone, London, E.11.

A SHORT summary of the views of Einstein, De Sitter, Friedmann, Eddington and others on the expanding universe is given by Paul Couderc in an article entitled "Les Théories de l'Universe en Expansion" (*l'Astronomie*, January 1953). The author holds the relativity theory of the expansion of the universe to be valid until proof to the contrary is forthcoming. The article is a useful synopsis of the author's more comprehensive treatment of the subject in "The Expansion of the Universe" (1952), translated by J. B. Sidgwick.

PLASTIC DEFORMATION OF METALS

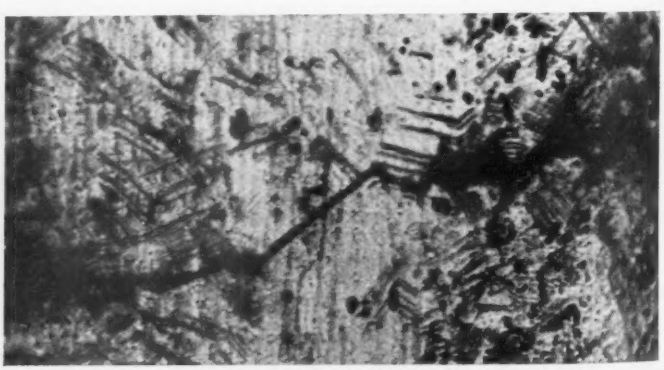
DURING July 15–16 a conference was held at the H. H. Wills Physical Laboratory of the University of Bristol on the plastic deformation of metals, with special reference to creep and fatigue. The conference was preceded during July 13–14 by a course of lectures by members of the staff of the Laboratory on recent developments in the theory of dislocations, especially on those which are relevant to the subject-matter of the conference. The course also included a review of the experimental evidence for the existence of dislocations. At the conference the following papers were given: D. McLean (National Physical Laboratory), a survey of recent work on creep; G. Masing (Göttingen), a survey of recent work in Göttingen on the deformation of metals; A. H. Cottrell (Birmingham), effect of twisting on the tensile strength of aluminium crystals; G. B. Greenough (Sheffield), residual strains in plastically deformed iron; J. Sawkill (Sheffield), deformation of gold crystals in pure shear; J. Nutting and G. Thomas (Cambridge), plastic deformation in two-phase alloys, and metallography of duplex slip; R. Cahn (Birmingham), some results on creep in zinc; A. G. Duce and G. C. Smith (Cambridge), surface markings in fatigue; J. W. Martin (Cambridge), fatigue of internally oxidized materials; A. K. Head (Melbourne and Bristol), the rate of spread of the fatigue crack; J. Clayton-Cave (British Iron and Steel Research Association, Sheffield), scatter of fatigue life; A. Deruyttere (Sheffield), cleavage fracture of zinc single crystals; C. E. Phillips (Mechanical Engineering Research Laboratory), a discussion of the size effect in fatigue; P. J. E. Forsyth (Royal Aircraft Establishment), a discussion of the work on fatigue at the Royal Aircraft Establishment, Farnborough.

After listening to the papers presented at this conference, it seemed to the present writer that, though we are beginning to understand the mechanism of plastic flow and work-hardening, the same cannot be said either of creep or of the various types of fracture. The discussion after McLean's able survey of creep showed that there was no agreement as to the rate-determining process. Both slip along the brain boundaries and deformation of the grains occur, and in principle either could control the rate. Those who maintained that it is the deformation of the grains with the accompanying cell formation or polygonization that matters had to explain how the grain size could affect creep-rate. One suggestion put forward was that, when the grain size is small, slip lines will frequently terminate on the grain boundaries, and that the annealing of the strains set up there would occur more rapidly, because of the ease of self-diffusion along the grain boundary.

Prof. Masing reported on the work of the Göttingen school on 'easy glide' of metal single crystals, on its dependence on orientation and on the surface markings which result. One fact which came out very clearly from his lecture was that, under conditions of easy glide in which slip on one system only occurs, deformation bands are formed. Deformation bands, with their accompanying X-ray asterisms, are therefore not directly related to work-hardening. Although the kinematics of their formation remains obscure, it is clear that they form a configuration of low energy in which dislocations can arrange themselves, and that dislocations trapped in this way are wasted so far as hardening is concerned. It seems that, in easy glide, dislocations either escape from the crystal or form deformation bands.

Turning now to fracture, there was considerable discussion of the work at the University of Sheffield on fracture of hexagonal metals, both single crystals and polycrystals. It was generally agreed that pre-existing Griffiths cracks are not the cause of fracture, but it was suggested that slip lines formed in the early stages of flow may act in a similar way. The stress around the end of a slip line is expected to be similar to that around the end of a crack, and thus to fall off with distance r from the end as $\sigma\sqrt{(l/r)}$, σ being the applied stress and l the length of the slip line. Just as, when the stress rises above a certain value, a Griffiths crack will extend, so, when the stress rises above a value of order $G\sqrt{(b/l)}$, we expect a crack to be initiated and to spread from the end of a slip line; b is here the interatomic distance. The linear relationship found at Sheffield between fracture stress and the reciprocal of the square root of the grain size suggests an explanation of this sort; if the stress exceeds a certain value, the first slip line formed crossing a grain breaks the specimen.

On the subject of fatigue, recent work at Melbourne, at the National Physical Laboratory, at Cambridge, and at Bristol on relatively pure non-ferrous metals revealed some measure of agreement as to what is observed. During the first thousand cycles or so the metal hardens and the area of the hysteresis loop greatly contracts, and towards the end of this process some slip lines appear. This occurs both with



A fatigue crack in copper obtained with a high-speed fatigue machine (Thompson and Wadsworth). × 280

the very slow machine developed at Bristol, taking several minutes for each cycle, and at frequencies of 1,000 c./s. Thereafter some of the slip lines broaden, according to Duce (Cambridge) these being those oriented in the direction of maximum shear stress. This goes on throughout the second stage of fatigue, which includes the bulk of the fatigue life. As regards the hysteresis loop, at Cambridge and at Melbourne it is found that its area remained constant during the second stage, whereas Thompson (Bristol) and the investigators at the National Physical Laboratory, working at different frequencies on the same copper, found a steady increase in the energy loss, together with the appearance of new slip lines. No obvious reason for the discrepancy was suggested. Also Thompson put forward results, confirming earlier work by Sinclair and Dolan[1], that frequent annealing does not increase the fatigue life of his copper specimens.

Head[2] (Melbourne) put forward a theory of the spread of a fatigue crack, obtained with many simplifying assumptions, but showing how, due to the work-hardening and subsequent fracture of the material just at the head of a crack, the slow growth of the crack might occur. He obtained the equation for the rate dc/dn per cycle at which the length c of the crack increases :

$$\frac{dc}{dn} = Ac^{3/2}; \qquad (1)$$

A is a constant which varies rapidly with stress and otherwise depends on such quantities as the rate of strain-hardening and the limit of ductility. He gave evidence to show that his equation is in reasonable agreement with experiment, at any rate for steels.

In view of the fact that damage which cannot be destroyed by annealing occurs early on, Head suggested that almost the whole fatigue life might be associated with the spread of a crack, and that equation (1) would account quantitatively for observed fatigue-lives if the crack were said to start from a length of 10^{-4} cm. On the other hand, Thompson showed some photographs of fatigue cracks in copper which suggest that initiation and spread of the crack are two separate processes. One of the photographs is shown in the illustration. It suggests that initiation involves the fracture of a single grain, in this case 10^{-2} cm. in width, and only after that does a crack spread by a mechanism as conceived by Head. As observed by several authors, cracks form in the heavily worked region of the broad slip lines. This, and the fact that early damage survives annealing, would suggest that the visible crack across a grain may result from a large number of small cracks which occur as the results of stress concentration at the ends of the slip lines in a single cluster.

No account can be given here of the various surface markings and cell structures which were discussed by contributors to the conference. Clearly the deformation of metals under alternating stress has many similarities to normal cold-work. An outstanding problem still remains, however, and that is why, over a significant range of stress, it takes as many as several million cycles to produce the effects observed.

[1] Sinclair G. M., and Dolan, T. J., Proc. Nat. Congress Appl. Mech., 647 (1952).

[2] Head, A. K., *Phil. Mag.* (in the press).

BIOCHEMISTRY OF LIPIDS

A THREE-DAY colloquium on the "Biochemical Problems of Lipids", sponsored by the Royal Flemish Academy of Sciences, was held recently in Brussels under the presidency of Prof. R. Ruyssen, of Ghent. The meeting was formally opened by Prof. E. Polinard, president of the Academy. The scientific programme was divided into three main sessions—the first dealing with the chemistry and physics of lipids and technical methods; the second being concerned with the intestinal absorption of lipids; the third with lipid biosynthesis.

The opening speaker of the first session was H. A. Boekenoogen (Unilever Research Laboratories, Zwijndrecht), who reviewed the chemical characteristics and classification of the more important lipids. Some discussion arose on the use of the term 'lipid'; it was generally felt that the wide biochemical use of the word should be retained and that the more specific chemical names available for individual lipids should be used when precise particularization is needed. The methods of dispersion of lipids in an aqueous medium and some of the factors concerned were discussed on the basis of papers in this field presented by D. Dervichian (Institut Pasteur, Paris) and P. Ekwall (Åbo). The separation of fatty acids by chromatography provoked discussion on a number of technical points following a paper on this subject by J. Boldingh (Unilever Research Laboratories, Zwijndrecht). C. Hocking (Cambridge), in a paper with J. H. Schulman (Cambridge), presented evidence of a model system that promoted the passage of negatively charged lipid particles through membranes.

Detailed consideration of molecular structure was provided by the discussion on the contributions of E. Klenk (Cologne), who described the investigation of the structure of long-chain polyethenoid fatty acids, and J. N. Hawthorne (Birmingham), who gave an account of the work he had undertaken to establish the structure of inositol-containing phosphatides derived from the soya bean. The association between lipids and proteins in biological structure was opened up by J. B. Finean (Birmingham), who gave a paper on his X-ray diffraction studies on nerve myelin. By studying the effect of drying, tension and the action of solvents, he was able to present useful data on the ultra-structure of myelin in both peripheral and optic nerve. The importance of lipids in cell structure was the subject of further debate in connexion with the membrane of the red blood cell, the stability of which formed the basis of two papers—one by R. Ruyssen (Ghent) and the other by B. A. Pethica (Birmingham).

Discussions during the second day on the intestinal absorption of lipids can be conveniently considered in relation to the three phases of absorption—intraluminar, cellular and distributive. Consideration of the intraluminar phase of absorption was opened by W. F. R. Pover (Birmingham), who described experiments on lipolysis, fine emulsification and the distribution of lipids between the oil and water phase. He presented evidence to show that both *in vitro* and *in vivo* the hydrolysis of long-chain triglycerides is likely to be incomplete, that the glyceride residue would be finely dispersed to a particle size of less than $0{\cdot}5\,\mu$ and that the long-chain fatty acids would be retained almost entirely in the oil phase, provided that the conditions approximated to those normally found in the upper small intestine. In contrast,

tributyrin is rapidly hydrolysed, is not emulsified and the butyric acid formed is dispersed about equally between the oil and water phase. P. Desnuelle (Marseilles) gave an account of the extensive study by his group of the products of lipolysis under various conditions. The rate of hydrolysis of different glycerides varies, and the reasons for this were discussed. B. Borgström (Lund) claimed that there is considerable re-formation of glycerides and transesterification, so that all the fatty acids in the glyceride may have been detached at some time in the course of the reaction. He agreed, however, that intestinal absorption of glycerides could occur without complete hydrolysis. After discussion it was generally agreed that the basic concept of the Pflüger–Verzár hypothesis that complete hydrolysis of glycerides is an essential step in fat absorption is not correct.

Consideration of the cellular phase of fat absorption was begun by H. G. Sammons (Birmingham), who discussed the passage of lipids through the outer border of the intestinal cell. He presented the evidence for considering that the outer border of the intestinal cell has a canalicular structure and described experiments on the absorption of long-chain and short-chain glycerides, paraffin, castor oil and water-insoluble esters, all of which illustrated in various ways the close relationship between fine emulsification in the intestinal lumen and absorption of the water-insoluble glyceride fraction. Considerable discussion followed, both on the structure of the outer border of the intestinal cell and on particulate absorption. P. Favarger (Geneva) presented a paper on the relationships between the absorption of glycerides and sterols, which, he felt, introduce the necessity for some transport mechanism more specific than simple oil-solubility. It might be that particulate absorption only carries lipids to the bottom of the fine canals and at this point some selective carrier mechanism for sterols might come into action. There do not appear to be sufficient data available at present to resolve these problems.

Consideration of the distributive phase of absorption was introduced by A. C. Frazer (Birmingham), who described the almost quantitative recovery of long-chain glycerides from the chyle. This lipid is finely emulsified and gives rise to the classical alimentary systemic hyperlipæmia. In human subjects with no pancreatic lipase as shown by intestinal intubation, no intraluminar emulsification and no alimentary hyperlipæmia occur. If a finely dispersed oil-in-water emulsion containing particles less than 0·5 μ in diameter is injected intraduodenally in such patients, a normal systemic hyperlipæmia occurs.

Certain lipids, however, are absorbed, but cannot be quantitatively recovered from the chyle. This has been observed in the case of short-chain fats and paraffins. These substances must either be metabolized in the intestinal cells or transported into the body by the alternative portal route. In the case of the shorter-chain fatty acids, transport in the portal vein has already been demonstrated, using decanoic acid labelled with carbon-14. The possibility of metabolic modification in the intestinal cell is an important consideration in the study of selective absorption. J. Fernandes, in collaboration with H. A. Weijers and J. H. Van de Kamer (Centraal Instituut voor Voedingsonderzoek, Utrecht), described studies carried out on a patient with a chylothorax. Long-chain fats were readily recovered from the chyle but short-chain fats were not. H. J. Thomasson (Unilever Research Laboratories, Zwijndrecht) described a new method for the biological assay of essential fatty acids.

The final session was opened by S. J. Folley (Reading), who described his classical work on the synthesis of lipids in mammary gland slices, with special reference to the influence of endocrine factors. J. Peeters (Ghent) continued with an account of his studies using the perfused udder. G. Popják (National Institute for Medical Research, London) presented the evidence for considering that fatty acids and cholesterol can be built up from 2-carbon fragments, and he described studies showing the synthesis of fatty acids from glucose labelled with carbon-14. R. Ruyssen (Ghent) described the incorporation of carbon-14 into fatty acids, and K. Bloch (Chicago) presented the evidence for the formation of cholesterol from squalene, and discussed the probable way in which this may occur. S. Bergström (Lund) gave an account of the methods he has developed for the detailed study of individual bile acids. K. Bernhard (Basle) described synthetic lipids containing triple bonds. This concluded the last scientific session.

The members of the colloquium decided to arrange future meetings from time to time, to discuss biochemical problems involving lipids. The Royal Flemish Academy of Sciences was thanked for its generous support, and the colloquium was formally closed by the president of the Academy. The full proceedings of the colloquium will be published in due course.

ANIMAL AND VEGETABLE RESOURCES OF GREAT BRITAIN

ABOUT five years ago suggestions were made to the Lord President's Office, in papers submitted by Dr. F. N. Woodward and Mr. A. N. Duckham, that more attention should be given in Britain to increasing the efficiency of the production and utilization of agricultural crops and other biological materials. Emphasis was placed upon possible uses for waste products, and it was pointed out that in the United States four regional laboratories had already been established for this purpose under the Bureau of Agricultural and Industrial Chemistry. Eventually, a team of three experts was chosen, made up of Dr. Woodward, Dr. A. B. Stewart and the late Mr. John Maxton, for the purpose of surveying all branches of industry concerned with biological, as distinct from mineral, products. The team proceeded to approach about two hundred individuals or organizations in the fields to be covered, including forty-two government departments, thirty-six research organizations, sixty-one industrial firms, twenty producers and manufacturers' organizations and twelve university departments. Its report, "A Survey of Agricultural, Forestry and Fishery Products in the United Kingdom and their Utilization", has recently been published under the auspices of the Development Commission*.

More than formal tribute is due to the memory of Mr. John Maxton, who was director of the Institute of Agrarian Affairs in the University of Oxford, for his editorial skill in condensing vast masses of important information into a report which is concise,

* Development Commission. A Survey of Agricultural, Forestry and Fishery Products in the United Kingdom and their Utilization. Pp. vi+141. (London: H.M.S.O., 1953.) 7s. 6d. net.

well arranged and pleasant to read. The subjects covered actually exceed the scope of the title in including imported agricultural crops which are processed in Britain, such as oil-bearing seeds, and also industrial biological products, such as malt, alcohol and antibiotics. Foodstuffs certainly predominate among the materials investigated, but attention is also given to non-edible products such as timber, leather, wool, cotton, paper and glue.

Agricultural crops. In Britain farmers grow only about one-third of the nation's wheat requirements, and nearly all the maize is imported. Almost all the barley and oats, however, are home grown. About half the barley is made into malt, and is used mainly for brewing and distilling; most of the rest is given to farm animals, which also receive nearly 80 per cent of the oats. The small quantity of home-grown rye is used for human consumption. The economical use of straw has attracted attention, and by predigestion with alkali its digestibility by animals has been increased. In the sugar beet industry the residual pulp left after the removal of the sugar has proved valuable as fodder, but an economical use for the foliage has still to be found. Pomace, left after pressing apples for making cider, is used both as fodder and as a source of pectin for the jam industry. Interesting regional differences are seen in the production of different vegetable crops in various parts of the country. Thus Ulster specializes in potatoes, Lincolnshire in peas and beans, and East Anglia in sugar beet. Peat is classified, perhaps rather strangely, as an agricultural crop; it contains about 12 per cent of wax which might be used for the manufacture of polishes and in electric cables. The imported crops which are processed in Britain include oil-bearing seeds, coffee, tea, cocoa, cotton, jute, hemp and tobacco.

Animal products. Milk is such an excellent food that it is wasteful, except when the production exceeds the demand, to use it other than in liquid form. It is satisfactory, therefore, that only 10 per cent of the output in Britain is used for making butter, cheese, dried milk and other products. In the meat industry little seems to be wasted, except quantities of blood which exceed the capacity of the processing plants. Whole dried blood is used as a fertilizer, and the separated albumin in making plywood and paint. Collections of organs and glands for the extraction of hormones and other medical products are now made on 85 per cent of the animals killed in government slaughter-houses. A valuable source of leather is lost because few pigs are flayed, because bacon and pork are best marketed with the skin intact. Wool fat is a rich source of various waxy alcohols and also of cholesterol, which is a valuable starting material for the synthesis of certain hormones and vitamin D_3. In the Bradford area no less than 8,500 tons of wool wax are recovered annually from the sewage; most of the wax is used on the railways as axle grease.

Biological products. The brewing industry, with all its ramifications, is based essentially on the culture of micro-organisms. It is estimated that 130,000 tons of carbon dioxide are given off annually in the course of brewing. The gas has several important industrial applications, but the supply far exceeds the demand. A more modern application of microbiology has been the production of antibiotics such as penicillin and streptomycin. The 'felt' formed by the micro-organisms is a rich source of vitamins of the B group. Starch is produced in Britain to the extent of 46,000 tons from maize, with only 2,100 tons from rice and 3,850 tons from wheat.

Timber. In Britain there is only 0·07 of an acre of forest per person as compared with 6·47 acres in Norway and 0·85 acre in Europe as a whole. The constant need to import timber, and the chronic scarcity of supplies, are therefore readily understandable. Steps are being taken to rebuild the stock of standing timber after the inroads made necessary by the Second World War. Although one cannot hope to satisfy current requirements, reserves may at least be accumulated against a future emergency. Most of the timber is located in Scotland. Attention is also being given to the efficient use of wood waste. Small pieces of wood and sawdust may be used to make hard-board, paper or briquettes for fire lighting. Vanillin may be manufactured from the sulphite liquor obtained in the manufacture of paper from wood. The liquor may also be fermented to give alcohol, yeast or other products.

Research and development. The report includes a useful list of the research institutions concerned in the production or efficient utilization of the materials which come within its scope. The absence or sparsity of the analytical data on many important products is stressed, and the collection of more adequate information is strongly urged. Another pressing need is the provision of more adequate facilities for investigating processes for industrial application on the 'pilot plant' scale. Only a few laboratories have any plant at all, and it is usually old-fashioned or even unserviceable. Practically no chemical engineers, moreover, are employed by the Department of Scientific and Industrial Research, and none by the Ministry of Agriculture and Fisheries or by the Agricultural Research Council.

The authors are to be congratulated for enabling research workers employed by these organizations, and others, to learn more of what is going on outside their own orbits of activity. The prosperity of Great Britain may largely depend on how far this widening and quickening of interest can be sustained and extended.

THOMAS MOORE

RESEARCH AND DEVELOPMENT AT NON-PROFIT INSTITUTIONS IN THE UNITED STATES*

A STUDY of the funds administered by United States Federal agencies for research and development at non-profit institutions during 1950–51 and 1951–52, which has recently been completed by the National Science Foundation, indicates the extent to which the Federal Government now sponsors research and development at such institutions, rather than conducting the work in its own laboratories. While in 1940 sponsored research and development accounted for less than 10 per cent of all government expenditure for this purpose, in 1952 it accounted for 75 per cent. According to the study, Federal agencies administered 338 million dollars for scientific research and development at non-profit institutions during 1951–52, compared with 294 million dollars

* The National Science Foundation. Federal Funds for Science. 1: Federal Funds for Scientific Research and Development at Non-profit Institutions 1950–1951 and 1951–1952. Pp. vi+48. (Washington, D.C.: Government Printing Office, 1953.) 30 cents.

during 1950–51. Such institutions received 16 per cent of all Federal research and development funds during 1950–51, but only 15 per cent during 1951–52. The distribution among administering agencies and receiving institutions, and the nature of the work sponsored, showed little variation between the two years.

During 1951–52, seventeen agencies of the U.S. Government sponsored research and development at non-profit institutions; but four agencies administered 98 per cent of the funds. The Department of Defense administered 53 per cent, the Atomic Energy Commission 36 per cent, the Federal Security Agency 5 per cent, and the Department of Agriculture 4 per cent. In the Department of Defense, the Department of the Navy accounted for 36 per cent of the total, or 64 million dollars, compared with the 62 million dollars of the Department of the Air Force and 51 million dollars of the Department of the Army.

Of the 427 recipient institutions, 403 were located in the United States, Alaska, Hawaii and Puerto Rico, and 295 million dollars went to 225 educational institutions, while three special research organizations, namely, the Brookhaven National Laboratory and the Oak Ridge Institute of Nuclear Studies, both of which are sponsored by the Atomic Energy Commission and operated under the joint auspices of groups of universities, and the Rand Corporation, which is operated by an independent organization, are closely related to educational institutions. The independent research organizations, forty-eight of which receive Federal grants, are, with the exception of the special research centres formed at the request of the Government, the sole institutional group with the primary purpose of conducting scientific research and development. Almost half these organizations, which received 17 million dollars during 1951–52, have been established within the past twenty years, and during the two years for which data are available the number of such organizations participating in Federal sponsored research and development increased from forty-three to forty-eight. During 1951–52, twenty-four research centres, defined as research and development projects, administered by non-profit institutions for the Federal Government, received funds; and all but three were operated by educational institutions, 47 per cent of the funds that went to non-profit institutions (or 159 million dollars) being received by these centres mainly for defence work or work related to defence.

Funds for programmes devoted primarily to scientific research and development amounted to 58 million dollars, and the total funds for support of research and development are estimated at about 75 million dollars, or rather more than 20 per cent of the total. During 1951–52 applied research received 5·1 per cent of the funds, development activity 22·9 per cent, and basic research 21 per cent. Most of the funds were assigned for work in the physical sciences, biological sciences during 1951–52 receiving 19 per cent, social sciences 3 per cent, increase of research and development plant 6 per cent, and the remainder going to the physical sciences. Of the recipient institutions, 39 per cent were universities, 18 per cent being professional technical schools and the remainder liberal arts colleges. Federal grants for the support of agricultural experimental stations were about 12 million dollars, and accounted for about a quarter of the funds available to the stations.

ISOTOPIC SPIN SELECTION RULES

By Dr. D. H. WILKINSON
Cavendish Laboratory, Cambridge

Isotopic Spin

It has long been recognized that, in some sense or other, the neutron and proton may be regarded as alternative states of the same particle, distinguished, without any specific assumption about nuclear forces, by the value of the isotopic spin co-ordinate[1]. The isotopic spin of the individual nucleon, the projection of which on the z-axis is represented by the value of the isotopic spin co-ordinate, bears a strong formal resemblance to ordinary intrinsic spin; the isotopic spin operators are closely related to the Pauli spin matrices. The idea of alternative nucleon states is suggested by the near-identity of the masses of neutron and proton, by their mutual interconversions that take place in ordinary beta-decay, by the beta-decay of the free neutron[2] and by the supposed role of charged mesons in connexion with nuclear forces; more recently we may add the transmutation of one nucleon into the other in reactions such as $p + p = p + n + \pi^+$ or $p + p = d + \pi^+$ (ref. 3) and $p + \pi^- = n + \pi^0$ (ref. 4).

The isotopic spin formalism has been widely used from the early days for computations concerning *few*-body nuclear systems; here it introduces nothing new but it makes the calculations look neater. If, however, we do not simply regard isotopic spin as a formal means of distinguishing neutron from proton but are prepared to link the formalism with a specific assumption concerning nuclear forces, we obtain novel results that are of considerable importance for the classification of *many*-body nuclear systems and for understanding certain apparently capricious aspects of nuclear reactions; it is not clear how certain of these results could be obtained outside the isotopic spin formalism except perhaps in a very cumbersome fashion. The assumption that we must make is that the specifically nuclear forces (that is, after allowing for the Coulomb and electromagnetic interactions) are independent of charge; n–n, p–p and n–p forces are equal in corresponding states. The total isotopic spin T of the system, formed from the isotopic spins of the individual nucleons according to the usual rules for the addition of angular momenta[1,5], then becomes a good, or almost good, quantum number, and its conservation in certain circumstances together with the selection rules governing its behaviour in others become matters of great physical consequence; the behaviour of the component along the z-axis, $T_z = \frac{1}{2}(N-Z)$, is generally trivial. Although we are unable, in any simple physical sense, to say what isotopic spin is, it is clear that the $2T + 1$ members of the isotopic spin multiplet represented by the $2T + 1$ values of T_z are simply all the different chemical elements that we may make from a given nuclear wave-function by turning neutron into proton and *vice versa* without change of that wave function before a halt is called by the Pauli exclusion principle. States that appear only in the self-conjugate ($T_z = 0$) nucleus are then of $T = 0$; those that appear also in the neighbouring isobaric nuclei of $T_z = \pm 1$ are of $T = 1$ and so on. The self-conjugate nucleus has the most states; those of $T = 0$ cannot be transferred to the neighbouring isobars by conversion of

neutron into proton and *vice versa*, since for them, but not for those of $T = 1$, the Pauli principle is opposed to this increase in the number of identical particles. We may think of these $2T + 1$ projections T_z of T as responding to the Coulomb perturbation in the same way as the $2J + 1$ projections of the ordinary spin J along the z-axis are shown up by the perturbation of a magnetic field.

A precise definition of isotopic spin may be given in terms of the symmetry properties of the nuclear wave function.

Independence of Charge

It is well known that the specifically nuclear forces are indeed, to a large degree, independent of charge[6]. The singlet scattering lengths of (the specifically nuclear) n–p and p–p interactions are closely the same, and the small difference may be susceptible of quantitative explanation in terms of the differing electromagnetic interactions[7]. The singlet effective ranges for n–p and p–p interactions are not very different, if at all[8]. Within the rather large limits of experimental error, the n–n singlet scattering length is the same as those for n–p and p–p interactions[9]. The familiar quantitative comparison of the level schemes of isobaric nuclei of odd mass shows rather generally the close equivalence of the n–n and p–p interactions[10,11] (including the many-body interactions); this is also displayed by a comparison of n–d and p–d scattering[12].

There is no experimental evidence that conflicts directly with this attractive and simple hypothesis of charge independence which may, in principle, receive a very simple theoretical explanation based on the meson field[13]; this, in turn, derives some support from the existence of the π-meson triplet showing apparently charge-independent interactions with single nucleons[4,14]. (Apparent violations of the hypothesis are seen in high-energy nucleon–nucleon scattering[15], but it is quite possible that these phenomena may be reconcilable with independence of charge[16]. Again, it may be argued that the slight difference in mass between neutral and charged π-mesons[17] shows that the specifically nuclear forces cannot be completely independent of charge, but this does not necessarily follow.)

Isotopic Spin Multiplets

If, then, we admit the independence of charge of the specifically nuclear forces, we must expect the $2T + 1$ members of a given isotopic spin multiplet to have the same spin and parity; if we allow for the Coulomb interaction and the neutron–proton mass difference, we must also expect that they will have the same mass. In particular, the ground-states of the two neighbouring isobars of a self-conjugate ($T_z = 0$) nucleus will be of $T = 1$ and of equal mass, the same as that of the first $T = 1$ state of the $T_z = 0$ nucleus (the ground-state of which is of $T = 0$). In order to test this experimentally, one must be able to identify the first $T = 1$ state of the $T_z = 0$ nucleus and to compute the differences of Coulomb energy between the three isobars. This is possible for the triplets ^{6}He—^{6}Li—(^{6}Be), ^{8}Li—^{8}Be—^{8}B, ^{10}Be—^{10}B—^{10}C, ^{12}B—^{12}C—^{12}N, ^{14}C—^{14}N—^{14}O and ^{16}N—^{16}O—(^{16}F). The computation of the Coulomb energy is very uncertain, but if we use the simplest possible model of a uniformly charged sphere of conventional radius we obtain the result shown in Table 1. The column labelled $T_z = 0$ shows the experimental excitation in MeV. of the first $T = 1$ level in the self-conjugate nucleus; the columns labelled $T_z = +1$ and $T_z = -1$ show the excitation at which this level is expected to appear in the self-conjugate nucleus from consideration of the masses of the ground-states of these neighbouring isobars; these masses are known to better than 100 keV. except where indicated, the uncertainty in mass then being transferred to the predicted excitation energy. The starred estimates are based on the masses of nuclei within 1 MeV. of instability against heavy-particle emission; the Coulomb correction is then particularly suspect. (The first successful comparison of this kind was made by Lauritsen[18].)

Table 1

Triplet	$T_z = +1$	$T_z = 0$	$T_z = -1$
^{6}He—^{6}Li—(^{6}Be)	4·0*	3·58	unstable
^{8}Li—^{8}Be—^{8}B	17·0	17·0	16·3 ± 0·3*
^{10}Be—^{10}B—^{10}C	1·9	1·74	2·0 ± 0·1
^{12}B—^{12}C—^{12}N	15·1	15·09	15·5 ± 0·1*
^{14}C—^{14}N—^{14}O	2·2	2·31	2·5 ± 0·1
^{16}N—^{16}O—(^{16}F)	12·7 ± 0·5*	12·51	unstable

The identification of these lowest $T = 1$ states in lithium-6, boron-10 and nitrogen-14 is almost certain, in beryllium-8 it is very probable, in carbon-12 probable, and in oxygen-16 rather unsure.

As yet no certain identifications of isotopic spin triplets corresponding to excited states of $T_z = \pm 1$ nuclei have been made, though tentative identification of the 3·37, 6·2 and 7·54 MeV. states of beryllium-10 may be made with the 5·16 (3·42), 7·48 (5·74) and 8·89 (7·15) MeV. states of boron-10, the 6·10 MeV. state of carbon-14 probably corresponds with the 8·06 (5·75) MeV. state of nitrogen-14, the 2·28 MeV. state of lithium-8 may well be partnered by the 19·18 (2·18) MeV. state of beryllium-8 and the 0·95 MeV. state of boron-12 by the 16·10 (1·01) MeV. state of carbon-12. (The energy in brackets is the height of the state above the first $T = 1$ state.) When virtual levels are involved, the Wigner–Thomas[11] shift must be taken into account; when this is done, the correspondence between these various excited states is good despite the fact that we have no real reason for expecting the Coulomb correction to be independent of the state of excitation.

If we bear in mind the extreme crudity, in these light nuclei, of our correction for the Coulomb energy, these data constitute strong evidence in favour of charge-independence and hence for the idea that T should tentatively be regarded as a good quantum number.

The Selection Rules

Heavy-particle reactions. If we admit T as a good quantum number, it must be conserved in heavy-particle reactions; this has some simple and immediate consequences: (i) if we form a nucleus in a well-defined excited state of isotopic spin T, it must break up in such a way that the vector sum of the isotopic spins of the resultant bodies is also T; for example, a state of $T = 1$ may not lead by alpha-particle emission to a state of $T = 0$ in the residual nucleus; (ii) if we carry out a reaction in which both incident and product particles are of $T = 0$ (for example, a (dd'), $(\alpha\alpha')$, $(d\alpha)$ or (αd) reaction) then the residual nucleus must be left in a state the isotopic spin of which is that of the target nucleus; for example, we may not excite a $T = 1$ state in a $T_z = 0$ nucleus by inelastic scattering of

deuterons since the target nucleus is of $T = 0$. It has indeed been found that we do not excite by this means the 3·58 MeV. state of lithium-6 [19], the 1·74 MeV. state of boron-10 [20] nor the 2·31 MeV. state of nitrogen-14 [19], which are all, following Table 1, of $T = 1$ (on independent evidence). We may similarly understand the failure of the 2·31 MeV. state of nitrogen-14 to appear in the reactions $^{16}O(d\alpha)^{14}N$ (ref. 21) and $^{14}N(\alpha\alpha')^{14}N$ (ref. 22) and be confident that, for example, the reaction $^{12}C(d\alpha)^{10}B$ will not readily leave boron-10 in the state at 1·74 MeV. The 8·89 MeV. state of boron-10 (probably $T = 1$, $J > 0$) leads by alpha-particle emission preferentially to the 3·58 MeV., $T = 1$ state of lithium-6 as may be expected[23]; no transitions are found to the two lower ($T = 0$) states of lithium-6. This aspect of isotopic spin conservation was stressed by Adair[24], who also pointed out that the cross-sections for competing nuclear reactions that lead alternatively to members of an isotopic spin multiplet should be closely related.

It is not likely that these selection rules will be of as wide interest if any of the particles involved in the reaction has odd mass, since states of $T = \frac{1}{2}$ are of considerable excitation in light nuclei and two particles of $T = \frac{1}{2}$ may give a resultant state of $T = 0$ or 1 (though if the reaction proceeds via a well-defined intermediate state the isotopic spin of that intermediate state must, of course, be conserved in its subsequent break-up).

Beta-decay. The isotopic spin selection rules on beta-decay were first considered by Wigner[25]: they are $\Delta T = 0$ (the transition must, in fact, be between members of the same isotopic spin multiplet) for Fermi, and $\Delta T = 0, \pm 1$ for Gamow–Teller selection rules. The distinction between these cases is not usually of practical interest in light nuclei since, as Christy has pointed out[26], when the isotopic spin changes by one unit so does the ordinary spin, and a transition without change of ordinary spin is also accomplished without change of isotopic spin.

Gamma-ray emission. Radicati[27] has remarked that the selection rule on any gamma-ray transition in any nucleus with the exception of electric dipole in a self-conjugate nucleus is also $\Delta T = 0, \pm 1$. (Radiative transitions, like beta-decay, are patently not independent of charge, so we should not expect isotopic spin to be of necessity conserved in them.) The chance of satisfactorily identifying, say, a state of $T = 2$ in a self-conjugate nucleus or one of $T = 3$ in a nucleus of $T_z = \pm 1$ appears to be rather remote, and so this rule and those on beta-decay are of but little practical interest. For electric dipole transitions in nuclei of $T_z = 0$, however, we have the important rule[27,28] $\Delta T = \pm 1$. This rule may be seen in operation in suppressing the transition from the (2 −) state at 5·11 MeV. in boron-10 to the (3 +) ground-state and the (1 +) states at 0·72 and 2·15 MeV.[29], that from the 6·91 MeV. (2 +) state of oxygen-16 to the (3 −) state at 6·14 MeV.[29,30], that from the 13·70 MeV. (2 −) state of neon-20 to the (2 +) state at 1·63 MeV.[31] and that from the 8·06 MeV. (1 −) state of nitrogen-14 to the (0 +) state at 2·31 MeV.[31]. The examples in boron-10, oxygen-16 and neon-20 are between states of $T = 0$; that in nitrogen-14 is between states of $T = 1$. It is unlikely that these transitions are missing on account of ordinary fluctuations in the electric dipole matrix element, since such fluctuations appear to be rather small in light nuclei[32]; that their absence is indeed due to the isotopic spin rule is made probable by the observation[33] that electric dipole transitions between states of $T = 1$ are in fact not forbidden in nuclei of $T_z = +1$.

Photodisintegration. Isotopic spin selection rules are potentially of great interest in certain photodisintegration reactions[28]. If we average over all gamma-ray energies, the principal contribution to the photodisintegration cross-section must come from electric dipole transitions[34]. When the target nucleus is self-conjugate, this cross-section cannot become large until we are able to excite states of $T = 1$ in the compound nucleus. This happens in all cases below the giant electric dipole resonances for (γp) and (γn) processes (at about 20 MeV. in light nuclei) and so is not of interest for them. But consider the situation if we are interested in $(\gamma\alpha)$ or (γd) processes: it is now not enough that the gamma-ray energy be sufficient to excite a $T = 1$ state in the compound nucleus, since such a state will not readily break up by deuteron or alpha-particle emission until there is enough energy available to leave the residual nucleus itself in a $T = 1$ state. Thus (γd) and $(\gamma\alpha)$ processes may be forbidden participation in the giant resonance, their cross-section rising at higher energy when a $T = 1$ state becomes available in the residual nucleus. This effect is dramatically seen[28,35] in the reaction $^{12}C(\gamma\alpha)^8Be$, which does not share the giant resonance at 22 MeV. in $^{12}C(\gamma n)^{11}C$ and $^{12}C(\gamma p)^{11}B$ because its Q-value is − 7·4 MeV. and so the first $T = 1$ state in beryllium-8 (at 17·0 MeV.) is inaccessible below a gamma-ray energy of about 25 MeV. Above 26 MeV. the cross-section for the $(\gamma\alpha)$ reaction does indeed rise—although the total cross-section is falling rapidly and has dropped to a small fraction of its peak value—and more than 95 per cent of the transitions lead by electric dipole absorption to a (2 +) state of beryllium-8 at 17·0 MeV. that must surely correspond to the ground-state of lithium-8 (see Table 1). That this 17·0 MeV. state is indeed of $T = 1$ is further suggested by the fact that its width against break-up into two alpha-particles is substantially less than 0·3 MeV. Similarly, the reaction $^{16}O(\gamma\alpha)^{12}C$ ($Q = -7{\cdot}1$ MeV.) above 24·5 MeV. leaves carbon-12 predominantly in its lowest $T = 1$ states at about 16 MeV.[28], and when enough energy is left in the residual carbon-12 it in turn breaks up by alpha-particle emission to leave beryllium-8 predominantly in its $T = 1$ state at 17·0 MeV.

Purity of Isotopic Spin States

We have so far supposed T to be a good quantum number; but in fact this cannot be so if only on account of the Coulomb perturbation that will mix states of differing isotopic spin (the effect of the charge-dependent electromagnetic interactions is relatively slight and may be neglected). The many successes, quoted above, of the raw isotopic spin selection rules show that isotopic spin states are, in fact, fairly pure; but we must now inquire what degree of purity is to be expected, and to what degree these rules may be relied upon. We may write in first-order perturbation theory:

$$\psi = \psi(T) + \sum_{T'} \alpha_T(T')\psi(T'),$$

where $\psi(T)$ is the wave function appropriate to isotopic spin T and $\alpha_T(T')$ measures its contamination, in amplitude, by a state of isotopic spin T'. If the process we are considering is forbidden for our state principally of isotopic spin T but allowed to one of T', it will occur at a rate $\alpha_T^2(T')$ times that expected

of it *a priori* with neglect of the isotopic spin rules.

Now consider only one contaminating state:

$$\alpha_T(T') = \frac{H^C_{T'T}}{E_T - E_{T'}},$$

where $H^C_{T'T}$ is the matrix element of the Coulomb perturbation between the states of T and T' the respective energies of which are E_T and $E_{T'}$ (they must, of course, have the same spin and parity). We may obtain a crude estimate of $\alpha_T(T')$ by noting that H will be measured in units of e^2 divided by e^2/mc^2, that is, a few tenths of a MeV., while $E_T - E_{T'}$ will be a few times the level spacing, that is, of order 10 MeV. for the lowest state of light nuclei. $\alpha_T(T')$ may then be expected to be of the order of a few per cent. This approach to the purity of isotopic spin states was made by Radicati[37], who computed $\alpha_T(T')$ for some specific examples on the basis of the shell model in L–S coupling and found values of $\alpha^2_T(T')$ ranging from $2{\cdot}5 \times 10^{-3}$ to 4×10^{-6}. We must, of course, expect that $\alpha_T(T')$ will increase with increasing excitation of the state considered, owing to the decreasing separation of the states of T and T'.

We must, then, expect the isotopic spin selection rules to be violated; if we test them severely enough the 'factor of discouragement' that they afford is measured by $\alpha^{-2}_T(T')$, which may be as much as 10^4 for the lowest states of certain light nuclei and approach unity at an excitation of perhaps 20 MeV., when the concept of isotopic spin will lose much of its significance.

We should also note that, even if T were a good quantum number, the selection rule on electric dipole transitions would not be strict. Gell-Mann and Telegdi[28] have pointed out that the matrix element is not zero for an electric dipole transition with $\Delta T = 0$ in a $T_z = 0$ nucleus, but is rather of order appropriate to a magnetic quadrupole transition[38]; the transition is not completely forbidden, but rather discouraged by a factor of order[39] $3 \times 10^6/E_\gamma^2$, where E_γ is the gamma-ray energy in MeV. Since this factor is still as large as 3×10^4 for $E_\gamma = 10$ MeV., this effect is unlikely to compete with isotopic spin impurity as the principal mechanism for the violation of the selection rule. (Of even less importance is the relaxation of the rule due to the differing masses of neutron and proton which would allow electric dipole emission to take place, but 10^6 to 10^7 times more slowly than in an uninhibited transition.)

It appears from this discussion of isotopic spin impurity that we may not apply the raw selection rules without consideration of the factor of discouragement that that application would imply, especially for states of high excitation where $\alpha^2_T(T')$ may be rather large. For example, consider a state of $T = 1$ that may decay by electric dipole emission to a $T = 0$ state or, so far as ordinary spin and parity are concerned, by alpha-particle emission to $T = 0$ states only. The raw selection rules suggest that gamma-rays should be emitted but not alpha-particles; however, the 'uninhibited' width for alpha-particle emission may well be 10^5 times greater than that for gamma-ray emission, and so alpha-particle emission will certainly remain the dominant mode even under the inhibition of the isotopic spin rule. Just such an example seems to be afforded[40] by the (1 −) state of oxygen-16 at 13·09 MeV. which decays five hundred times more readily by alpha-particle emission to $T = 0$ states of carbon-12 than by electric dipole radiation (of large radiative width) to the ground state of oxygen-16; this is probably a $T = 1$ state with a large value of $\alpha^2_1(0)$ such as we may reasonably expect at such high excitation.

Other examples of violation of the raw rules are afforded by the observed electric dipole transition from the 7·12 MeV. (1 −) state of $T = 0$ in oxygen-16 to the ground-state[29,30], by the formation of the 5·16 MeV. (2 +) state of $T = 1$ in boron-10 by the bombardment of lithium-6 with alpha-particles[29] and by the emission of alpha-particles to $T = 0$ states from the following probable $T = 1$ states: 17·0 MeV. in beryllium-8, 7·48 MeV. in boron-10, 15·09 and 16·10 MeV. in carbon-12, 12·51 MeV. in oxygen-16. The 7·48 MeV. state of boron-10 also probably emits deuterons to the ground-state of beryllium-8. From these various examples we may place limits on $\alpha^2_T(T')$ for several states. The results are summarized in Table 2 where, it must be emphasized, the estimates of $\alpha^2_T(T')$ are rather crude in many cases.

These values of $\alpha^2_T(T')$ are all consistent with what is expected of the Coulomb perturbation of a specifically nuclear interaction completely independent of

Table 2

Nucleus	Level	T	T'	Reaction	$\alpha^2_T(T')$	Status	Ref.
^{6}Li	3·58	1	0	^{6}Li(dd')^{6}Li	$< 0{\cdot}02$	*A*	19, 41
^{6}Li }	0 }	0	1	^{6}Li($a\gamma$)^{10}B	$> 10^{-3}$	*A*	29
^{10}B }	5·16 }	1	0	^{6}Li($a\gamma$)^{10}B	$> 10^{-3}$	*B*	29
^{8}Be	all $< 17{\cdot}0$	0	1	^{12}C(γa)^{8}Be	$< 0{\cdot}05$	*A*	28, 35
^{10}B	1·74	1	0	^{10}B(dd')^{10}B	$< 0{\cdot}04$	*A*	20, 41
^{10}B	5·11	0	1	^{6}Li($a\gamma$)^{10}B	$< 3 \times 10^{-3}$	*A*	29
^{10}B	5·16	1	0	^{10}B(dd')^{10}B	$< 0{\cdot}2$	*B*	42
^{10}B	7·48	1	0	^{9}Be($p\alpha$)^{6}Li	$> 10^{-3}$	*A*	43
^{10}B	7·48	1	0	^{9}Be(pd)^{9}Be	$> 2 \times 10^{-3}$	*A*	43
^{12}C	all $< 15{\cdot}0$	0	1	^{16}O(γa)^{12}C	$< 0{\cdot}1$	*A*	36
^{12}C	16·10	1	0	^{11}B(p,a)^{8}Be	$> 10^{-3}$	*B*	10
^{14}N	2·31	1	0	^{14}N(dd')^{14}N	$< 0{\cdot}1$	*A*	19, 41
^{14}N	2·31	1	0	^{16}O(da)^{14}N	$< 0{\cdot}1$	*A*	21
^{14}N	8·06	1	0	^{13}C($p\gamma$)^{14}N	$< 0{\cdot}02$	*A*	31
^{16}O }	6·14 }	0	1	^{19}F($p\alpha$)^{16}O	$< 10^{-3}$	*A*	29, 30
^{16}O }	6·91 }	0	1	^{19}F($p\alpha$)^{16}O	$< 10^{-3}$	*A*	29, 30
^{16}O	7·12	0	1	^{19}F($p\alpha$)^{16}O	$> 4 \times 10^{-6}$	*A*	29, 30
^{16}O	12·51	1	0	^{15}N($p\alpha$)^{12}C	$> 0{\cdot}1$?	unsure	10
^{16}O	13·09	1	0	^{15}N($p\alpha$)^{12}C	$> 0{\cdot}03$	*A*	40
^{20}Ne	13·70	0	1	^{19}F($p\gamma$)^{20}Ne	$< 0{\cdot}04$	*B*	31, 44

The excitations are in MeV.: status *A* means that the stated value of T is almost certain, status *B* means that it is probable only. The bracketed levels contribute together the stated impurity. In obtaining these estimates use has been made of the single-particle gamma-ray widths[32,33] and the Wigner limit for heavy particle emission[45]. (The figure for the impurity of the 7·12 MeV. state of oxygen-16 merely indicates the strength of the transition and neglects the magnetic quadrupole effect mentioned above; this effect is of itself, sufficient to produce the observed apparent violation of the isotopic spin selection rule even for $\alpha^2_0(1) = 0$.)

charge. It appears that Table 2, taken in conjunction with the evidence of the isotopic spin multiplets (see above and Table 1), supports the idea of independence of charge and suggests that the isotopic spin selection rules may be applied with confidence to states of light nuclei, although their limited power as reflected in the finite value of $\alpha_T^2(T')$ must always be borne in mind.

In this connexion it is interesting to note a suggestion of T. Lauritsen[46] that many well-defined states of high excitation in $T_z = 0$ nuclei that are capable of emitting energetic alpha-particles (say above an excitation of about 13 MeV. in neon-20, for example) may owe this definition to their being principally of $T = 1$ and therefore having alpha-particle widths about $\alpha_1^{-2}(0)$ times smaller than $T = 0$ states which may be so broad as to be unobserved.

Charge Parity

The whole of the foregoing discussion has been based on the notion of the *charge-independence* of nuclear forces which is indeed demanded if we accept the evidence of the masses of the isotopic spin multiplets. However, if we relax this postulate of charge-independence into one of *charge-symmetry*—suppose only that *n–n* and *p–p* forces are equal and ignore the relative magnitude of the *n–p* forces—interesting selection rules still emerge. The evidence for this less restrictive charge-symmetry is rather more extensive than that summarized above for charge-independence but is of the same quality. It is now clear that we may define, but in self-conjugate nuclei only, a new quantum number, charge parity[47], that is odd or even according to whether the nuclear wave-function does or does not change sign when all neutrons are changed into protons and *vice versa*. Within the more general framework of charge-independence, the charge parity operator is associated with a rotation about the x (or y) axis in isotopic spin space, and the charge parity itself is odd or even according as to whether T is odd or even. Kroll and Foldy[47] have pointed out that, if we limit ourselves to reactions of self-conjugate nuclei, consideration of charge parity alone, and hence charge-symmetry alone, suffices to reproduce most of the isotopic spin results discussed above that have much practical importance. The rules are that, in heavy-particle reactions, charge parity is conserved while in the emission of electric dipole radiation (only) charge parity must change.

All experimental results connected with selection rules so far available do in fact refer to self-conjugate nuclei with T less than 2, and so, taken in isolation, bear strictly only upon the problem of charge-symmetry. But the evidence of the isobaric multiplets is in itself sufficiently strong to encourage the adoption of the fuller hypothesis of charge-independence and the use of the language of isotopic spin, although the justification for this on the basis of selection rules alone should properly await the identification of states of higher isotopic spin.

Meson and High-energy Processes

The principal concern of this account has been with the effect of independence of charge in light nuclei; but it must be mentioned that it is also of great importance in discussing high-energy interactions of nucleons and simple systems[48] and in determining relationships between various processes involving meson scattering and production[49]. Owing to the existence of the apparently symmetrical π-meson triplet with strong coupling to the nucleus, it becomes sensible to regard the π-meson as of isotopic spin one.

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LETTERS TO THE EDITORS

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A New Type of Helium Liquefier

TWENTY-FIVE years ago, one of us[1] suggested an 'external work' machine to be used for the liquefaction of the gases of low boiling point, in particular helium and hydrogen, in a process similar to that used by Claude for the liquefaction of air[2]. The essential feature of the suggestion was to replace the conventional cylinder and piston of the expansion engine by one constructed from an elastic metal bellows. Such a bellows engine would form a gas-tight unit which could be suspended in a vacuum for thermal insulation, and one would expect the engine to operate with a high degree of reversibility. Though it was experimentally verified at the time that metal bellows could be used at hydrogen temperatures, the design of an engine was not pursued because the problem of fatigue fracture seemed to require extensive development work.

Since then, Kapitza[3] has built a helium liquefier incorporating an expansion engine in which a loose-fitting piston allowed gas to escape and so provide lubrication. Several people have built liquefiers based on Kapitza's original work, and Collins[4], in particular, has developed this type of liquefier into a commercially produced machine which has contributed much to the widening of low-temperature research.

As we believed that a simpler and much less expensive liquefier could be built using the bellows principle, we began, about three years ago, the design of such a liquefier. Our early experiments[5] showed, fortunately, that the fatigue-life increases as the temperature decreases and that the low-temperature life of commercially available bellows was sufficient to warrant the construction of a liquefier. The liquefier has now been in operation for the past seven months, and this is a brief report of its design and performance.

We used a bellows of 7·7 cm. outer diameter, 4 cm. inner diameter and 5·4 cm. length with fifteen convolutions. It is hydraulically formed from brass, one end being closed. The other end of the bellows is fitted with a cup which houses the valves and displaces most of the internal volume when the bellows are completely compressed. The valve cup is suspended in the centre of a vacuum case on a thin-walled stainless-steel tube. The inlet gas forces the lower end of the bellows downward as it expands, thus allowing the use of a thin tension rod to transmit the motion to a mechanism at room temperature where the work is dissipated. The valves are also operated by tension rods. The engine normally runs at 2-3 cycles per sec. The life of the bellows under the present operating conditions of 5·5 atmospheres inlet pressure and the very considerable stroke of 2·7 cm. is about 5×10^5 cycles.

The heat exchangers and the liquid helium container are housed in the vacuum case, which is surrounded by a glass Dewar vessel containing liquid air for pre-cooling the gas. Helium gas at 20 atmospheres is supplied at the rate of 15 cubic metres per hr. (N.T.P.): 70 per cent is reduced to 5·5 atmospheres for the engine supply, while the remainder, after being cooled by the expanded gas from the engine, enters a Joule–Thomson liquefying stage.

At present the liquefier produces 0·4 lit. of liquid helium per hr., consuming 1·2 lit. of liquid air. This liquefaction rate is not the optimum value, as the output of the engine is not fully utilized because of heat leaks and inefficiency in the heat exchangers. A second liquefier is being designed in which these defects will be remedied. Although some work is still needed to find the optimum operating conditions for the engine as well as the most suitable material for the bellows, we feel that the bellows liquefier is an attractive method of producing liquid helium and, in particular, that fatigue failure will not be a serious obstacle.

A detailed description of the apparatus will be published elsewhere in the near future.

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Aug. 19.

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Estimation of Heterogeneity from Diffusion Measurements

IN order to estimate heterogeneity of molecular weights (in proteins) from diffusion measurements, Charlwood[1] uses the relation

$$\sigma/D_{2,0} = \sqrt{\left\{\frac{\Sigma\alpha_i D_i^2}{\Sigma\alpha_i D_i}\Big/ \Sigma\alpha_i D_i - 1\right\}} = \sqrt{\{D_{4,2}/D_{2,0} - 1\}}, \quad (1)$$

where D_i is the diffusion constant for the weight fraction α_i (in the sense of probability density), and σ the standard deviation of D_i. In terms of the absolute moments, $m_i = \int_{-\infty}^{+\infty} |x|^r y\, dx$ of the refractive index gradient curve this becomes

$$\sigma/D_{2,0} = \sqrt{\left\{\frac{m_4 m_0}{3m_2} - 1\right\}}. \quad (1a)$$

Experimental measurements have led Charlwood to believe that in view of the unavoidable experimental and computational errors it seems unlikely that it will be possible to use $[D_{4,2}/D_{2,0} - 1]^{1/2}$ as an estimate of $\sigma/D_{2,0}$ when that quantity is very small, and he, therefore, suggests that in such cases there is no other choice but to fall back on the ratio

of the lower moments $D_{2,0}/D_A = \Sigma\alpha_i D_i \Big/ \left[\frac{1}{\Sigma\alpha_i/\sqrt{D_i}}\right]^2$

as a *semi*-quantitative estimate of the heterogeneity. The use of the fundamental relation between the ratio of averages of different order and the standard deviation[2] is, however, not restricted to the ratio $D_{4,2}/D_{2,0}$, and it will be shown that it is possible to obtain from a knowledge of $D_{2,0}$ and D_A a *fully* quantitative estimate of heterogeneity, since the difference $D_{2,0} - D_A$ turns out to be a measure of the standard deviation of $\sqrt{D}$.

We first note that $\sqrt{D_A} = \frac{1}{\Sigma\alpha_i/\sqrt{D_i}}$ is the harmonic

mean of the weight distribution of $\sqrt{D}$. We then write the standard deviation of $\sqrt{D}$ as

$$\sigma^2(\sqrt{D}) = \Sigma\alpha_i D_i - [\Sigma\alpha_i\sqrt{D_i}]^2. \qquad (2)$$

Since the harmonic mean is by necessity equal or smaller (according to whether the distribution curve is symmetrical or skew) than the arithmetic mean, substitution of $\frac{1}{\Sigma\alpha_i/\sqrt{D_i}}$ in place of $\Sigma\alpha_i\sqrt{D_i}$ leads to the inequality

$$\sigma^2(\sqrt{D}) \leqslant \Sigma\alpha_i D_i - \left[\frac{1}{\Sigma\alpha_i/\sqrt{D_i}}\right]^2 = D_{2,0} - D_A. \qquad (3)$$

In words: the difference between the weight mean and area mean of the diffusion constant represents an upper bound to the variance of the square root of the diffusion constant; and

$$\frac{\sigma^2(\sqrt{D})}{D_A} \leqslant D_{2,0}/D_A - 1. \qquad (3a)$$

In words: the ratio of weight to area mean minus unity represents an upper bound to the variance of the relative fluctuation of the square root of the diffusion constant. In terms of the moments of the refractive index gradient curve,

$$\frac{\sigma^2(\sqrt{D})}{D_A} \leqslant \frac{2\pi H^2 m_2}{m_0^3} - 1, \qquad (3b)$$

where H is the maximum height of the curve.

If we wish to test the correctness of formula (3) we can do so by means of the approximate relation applying under certain conditions between the standard deviation of a variate and that of its square root[3]:

$$\sigma^2(\sqrt{x}) = \frac{1}{4}\cdot\frac{\sigma^2(x)}{\bar{x}} \qquad (4)$$

$$\text{or } \sigma(\sqrt{x}) = \frac{1}{2}\cdot\frac{\sigma(x)}{\sqrt{\bar{x}}}, \qquad (4a)$$

where x is the arithmetic mean of the variate x.

In our case, where only an upper bound for $\sigma(\sqrt{x})$ is available, (4a) becomes

$$(D_{2,0} - D_A)^{1/2} \geqslant \frac{1}{2}\cdot\frac{\sigma(D)}{\sqrt{D_{2,0}}}. \qquad (4b)$$

The quantities in formula (4b) are for sucrose + glycine and bovine plasma + sucrose given in the accompanying table:

		$D_{2,0}$	$D_{2,0} - D_A$	$\sigma^2(D)$
(a)	Sucrose and glycine	78·0	6·0	240·0
(b)	Bovine plasma albumen + sucrose	35·1	14·3	446·0
		From Charlwood's Table 2.		Calculated by equation (1)*.

Substitution into (4b) gives:

$$(a)\quad 2{\cdot}45 \geqslant \tfrac{1}{2}\cdot\sqrt{\frac{240}{78}} = 0{\cdot}9$$

$$(b)\quad 3{\cdot}8 \geqslant \tfrac{1}{2}\cdot\sqrt{\frac{352}{35{\cdot}1}} = 1{\cdot}6$$

As predicted by (3), the quantity $(D_{2,0}-D_A)^{1/2}$ represents an upper bound to $\sigma(\sqrt{D})$, as estimated by (4).

The values of $\sigma(D)$ are here, of course, only used for the sake of the test, the purpose of this paper being to devise a measure of heterogeneity for cases where the value for $\sigma(D)$ obtained from (1) is unreliable. If, however, $\frac{\sigma(D)}{D_{2,0}}$ is not very small, the above relation, involving then reliable estimates of both $\sigma(\sqrt{D})$ and $\sigma(D)$, affords in the amount of inequality a measure of skewness of the distribution of D_i, provided (4) is suitable for the distribution in question.

* From the average of the corrected values of $D_{4,2}/D_{2,0}$.

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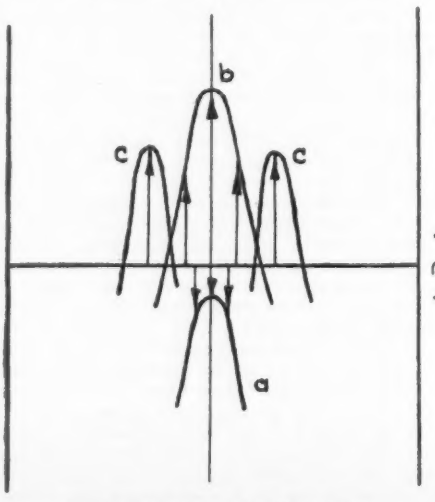
Axial Flow in a Vortex

A recent study of swirling fluid flow in a circular pipe has unexpectedly shown that reverse flow occurs in the centre of the pipe for some rates of swirl and discharge.

The experimental apparatus consisted of a $2\frac{7}{8}$-in. inside diameter 'Perspex' pipe set vertically and surmounted by a cylindrical tank containing a ring of guide vanes which produced the swirl (free vortex). The rate of discharge was controlled by throttling at the lower end of the 56-in. length of pipe and by adjusting the inflow to maintain a constant free surface-level in the tank. Several different throttling devices were used, such as a circular orifice, a divergent cone terminating in a flat plate with an orifice, an annular orifice, etc. These were designed to give an average axial velocity of 1·5 ft./sec., $R = 3\times10^4$. The flow at $R = 1\times10^4$ was investigated with a smaller circular orifice. Dye was used for indicating fluid path lines but no quantitative velocity measurements were made.

At low rates of swirl the axial velocity at the pipe centre was less than the maximum as shown by curve *a*, in the figure. As the swirl was increased the axial velocity became negative at the centre (curve *b*), and finally, for higher rates of swirl, the axial velocity was positive at the centre but negative in a narrow region between the axis and the wall (curve *c*).

The type of throttling device determined the rate of swirl at which the transition from curve *a* to *b*



Reverse flow in a circular pipe with a vortex

and curve *b* to *c* took place. It was possible to reproduce curve *c* with the circular and annular orifices only, and the transition from curve *b* to *c* occurred at a lower rate of swirl with the circular orifice. No qualitative change in the flow pattern could be seen between a point 8 in. above the outlet and the tank bottom, which was 6 in. below the inlet.

So far no satisfactory explanation of this phenomenon has been found. It seems to be related to the reverse flow at the centre of a Ranque–Hilsch vortex tube, although no thermal effects are present in this case.

These experiments were made in the Hydraulics Laboratory of the City and Guilds College, London, by permission of Prof. C. M. White.

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Importance of Ion Exchange with the Solvent in Kinetic Studies

IN kinetic examination of nucleophilic substitution and elimination reactions with various attacking ions Y' in alcohol solution, Bunnett and Zahler[1] directed attention to complications likely to arise from the replacement of Y' by OEt′ consequent upon the equilibrium:

(I) $\quad Y' + \text{HOEt} \rightleftharpoons HY + \text{OEt}'.$

In extension of our earlier work[2] on the effect of various nucleophilic reagents on the simultaneous substitution (II) and carbonyl elimination (III) reactions of organic esters of nitric acid, we have now obtained definite evidence of the great importance of such ion replacement reactions. We record below the separate values of the second-order velocity coefficients (in gm.mol.$^{-1}$ lit.sec.$^{-1}$) for the reactions:

(II) $Y' + \text{PhCH}_2\cdot\text{O}\cdot\text{NO}_2 \rightarrow \text{PhCH}_2Y + \text{NO}_3'$ $\quad (S_N2)$

and (III) $Y' + \text{PhCH}_2.\text{O}.\text{NO}_2 \rightarrow \text{PhCH:O} + HY + \text{NO}_3'$ $\quad (E_{CO}2)$

for attack by *initially* added Y' = OEt′, OH′ and OPh′ on benzyl nitrate in 100 per cent ethanol solution at 60·2°.

The nearly equal values (Nos. 1 and 2) of the velocity coefficients for OEt′ and OH′ suggest that actual attack is essentially by OEt′ in both experiments, in harmony with the independent findings of Caldin and Long[3].

With OPh′ (No. 3), the value of $kE_{CO}2$ exhibits a marked downward drift as the reaction proceeds. Such a drift should occur if the formation of free phenol in reaction (III) causes a gradual displacement of the equilibrium (I, Y' = OPh′) towards the left as the reaction proceeds. Initial addition of free phenol to the reaction mixture, in concentrations sufficient to swamp the small amount produced in reaction (III), should, by a mass law effect, cause more-or-less complete suppression of OEt′. The experimental value of $kE_{CO}2$ thus obtained should approach the true value for attack by phenoxide ion.

It was found that such additions of free phenol in increasing concentrations (*a*) cause successive decreases in $kE_{CO}2$ towards an asymptotic value, and (*b*) gradually eliminate the drift in the constant. In the presence of 0·3 *M* phenol (No. 5) $kE_{CO}2$ has been reduced to about one-ninth of the original value and remains constant throughout the experiment. The true value of $10^5kE_{CO}2$ for OPh′ cannot, therefore, be greater than 5·3, and extrapolation suggests that it may be as low as 2–3. Within this range, however, the actual value makes no significant difference in the following deductions.

This value, together with that for ethoxide ion (No. 1), permits calculations of the changing concentration of OPh′ and OEt′ present throughout experiment No. 3. They reveal that, although [OPh′]/[OPh′] + [OEt′] = 0·97 → 0·98, because of the much greater nucleophilic power of OEt′, approximately 90 per cent of the total carbonyl elimination is effected by ethoxide ion. Even in experiment No. 5 it is still approximately 10 per cent. Incidentally, it will be noticed that the replacement of OEt′ by OPh′ has a much smaller effect on kS_N2 than on $kE_{CO}2$, in agreement with the well-known fact that, with decreasing basic strength, the nucleophilic power of the reagent towards hydrogen diminishes much more rapidly than it does towards carbon.

Our data also permit an approximate assessment of the value of the equilibrium constant K = [OEt′] [PhOH]/[OPh′] [EtOH] as ~10^{-5}.

The important implications of these conclusions on the validity of previously published results for attack of various nucleophilic ions in proton-donating solvents are obvious. Our investigations are being extended and will be published in full elsewhere when they are complete.

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Exp. No.	Y'	Added HY	Initial concentrations [$PhCH_2NO_3$]	Initial concentrations [Y']	10^5k_2 S_N2	10^5k_2 $E_{CO}2$
1	OEt′	—	0·0301	0·0366	96·7	1,350
2	OH′	—	0·0265	0·0406	99	1,440
3	OPh′	0·006 *M*	0·0498	0·0946	74·2	48·6 → 36·9*
4	OPh′	0·236 *M*	0·0524	0·1010	60·5	6·3 ± 0·09†
5	OPh′	0·322 *M*	0·0478	0·0897	61·4	5·3 ± 0·06†

* Coefficient drifts throughout run. † Coefficient constant thoughout run.

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Equilibrium between Ethoxide and Hydroxide Ions in Ethanol

THERE is some evidence[1,2] that, in solutions made by dissolving sodium hydroxide in ethanol, much of the hydroxyl ion is replaced by ethoxide, the equilibrium $OH^- + EtOH \rightleftharpoons OEt^- + H_2O$ lying well to the right. We have confirmed this by measuring the equilibrium constant $K = [OEt^-][H_2O]/[OH^-][EtOH]$ at 25° C., using solutions made by dissolving sodium or sodium hydroxide in ethanol–water mixtures containing 10–50 per cent water by weight. The method adopted makes use of the fact that trinitrotoluene ionizes to give an intensely coloured ion in the presence of ethoxide[3].

The concentration of ethoxide ion in the solutions can thus be determined colorimetrically, and that of hydroxide ion can then be found by determining the total base concentration by titration.

The results show a regular trend with solvent composition (the activity coefficients have not been included in K); they can, however, be extrapolated to zero water concentration, whence we find that in pure ethanol $K = 0{\cdot}7 \pm 0{\cdot}2$. This implies that in a solution made by dissolving sodium or sodium hydroxide in ethanol containing x per cent water by weight, the percentage p of the base which is present as ethoxide ion is (if the concentration of base is not so large as to alter appreciably the percentage of water in the solvent) as follows:

x	0·2	0·5	1·0	2·0	per cent water
p	99	98	96	94	per cent ethoxide

These results are in agreement with the kinetic evidence of Baker and Neale[2], and also explain why the addition of water (1 per cent) has little effect on the rate or equilibrium of the reaction between ethoxide ion and trinitrotoluene or similar substances in ethanolic solution[4].

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June 17.

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Mercuric Oxychloride as Tri-chlormercury-oxonium Chloride

Little is known about the relations between the mercury and oxygen atoms in the crystal lattices of mercury compounds containing oxygen. We decided, therefore, to determine the structure of the most important representatives of this class of compounds by the use of the X-ray diffraction methods. We started our investigations with the study of the so-called mercury oxyhalides, among which the mercuric as well as the mercurous derivatives are known[1].

The crystal structure of these oxyhalides is of special interest. According to their chemical formulæ, it should contain components which, when alone, crystallize in lattices of an entirely different type. Consequently, the role of the oxygen atoms in the lattice of these compounds can scarcely be foreseen.

The present communication briefly reports the result of the X-ray analysis of the single crystal of an oxychloride quoted in the literature under the formula $2HgCl_2.HgO$.

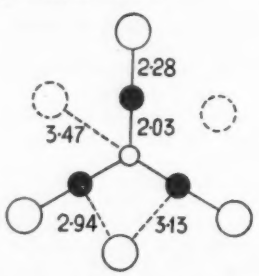
Its crystals belong to the cubic tetartohedral class. The unit cell edge is $a = 9{\cdot}22$ A. (thus we have confirmed the value $a = 9{\cdot}21$ A. obtained already by Gawrych[2] from the powder photographs). The space group is T^4-P2_13, with four formula units in the elementary cell.

Copper $K\alpha$ radiation was used, and all possible $hk0$ reflexions were recorded with the help of a Weissenberg goniometer. The relative intensities were determined from the optical densities which had been measured with the use of a microphotometer. The absorption correction was carried out very carefully, since the absorption of X-rays in the crystal is very high ($\mu = 124$ mm.$^{-1}$). For this purpose, a prismatic shape was given to the specimen by grinding, and the absorption factors were calculated with the help of formulæ[3].

In the Patterson projection on the (001) many overlappings of the maxima occurred. Nevertheless, it was successfully interpreted by Bezjak's[4] modification of the vector algebraic method described by Lindqvist[5], and the preliminary co-ordinates of the mercury atoms were thus obtained. It followed that the mercury atoms are located in the general positions.

With the help of these mercury parameters, the signs of the structure amplitudes $F(hk0)$ were determined, neglecting the contribution of the chlorine and oxygen atoms, and the projection of electron density distribution by Fourier synthesis was computed. The signs were then recalculated (the contribution of the chlorine atoms being taken also into account), and the second Fourier synthesis evaluated, from which the final atomic co-ordinates were obtained. The maxima of all atoms were well resolved. The diffraction effect exerted a more pronounced influence only on the parameters of one chlorine atom which came out in the projection close to the mercury atom. The structure may be described as follows.

The oxygen atom located on the triad axis is surrounded by three mercury atoms in the same plane, the distance O—Hg being 2·03 A. On each mercury atom the chlorine atom is linked at a distance of 2·28 A. in such a manner that oxygen, mercury and chlorine atoms lie almost exactly in a straight line. The fourth chlorine atom is situated on the triad axis and is thus crystallographically different from the remaining three. The distance from the oxygen atom is 3·47 A., and from the two adjacent mercury atoms 2·94 A. and 3·13 A., respectively. Consequently, each oxygen atom has three such neighbouring chlorine atoms.



●, Mercury; ○, oxygen; ○, ○, chlorine

The different function of the chlorine atoms in this compound was already assumed by Lamure[6] from purely chemical considerations, but the structural formulæ proposed by him are inconsistent with the result of our investigation.

From the values of the interatomic distances, it follows that the $(ClHg)_3O$ group is to be considered as a complex cation, the anion being the chlorine atom in the special position. Mercury oxychloride $2HgCl_2.HgO$ is therefore in reality a tri-chlormercury-oxonium chloride $[(ClHg)_3O]Cl$. The detailed description of the structure with all atomic co-ordinates will be given elsewhere.

Obviously, this result gives us no right to assume that other mercury oxychlorides are also oxonium

compounds, and further investigations in this field are in progress.

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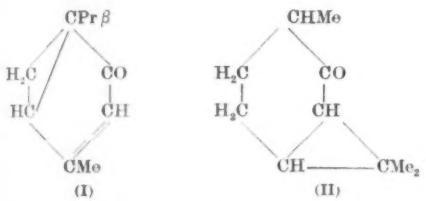
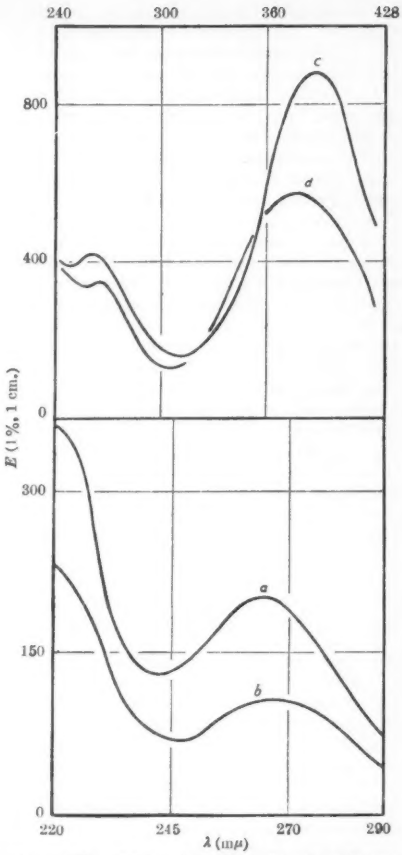
Some New Derivatives of Umbellulone

Semmler's structure (I) for umbellulone has been supported in recent years by the synthesis of some of its derivatives by Phillips, Ramage and Simonsen[1], Rydon[2] and Guha and Muthanna[3]. A useful review of this and other work has been given by Simonsen[4].



The absorption spectrum of umbellulone, however, is quite different from that of a simple α,β-unsaturated ketone (Gillam and West[5]), and exhibits two bands, each of fairly high intensity (see graph). The success of Gillam and his co-workers[6] in resolving the absorption spectrum of *iso*cadinene into components by chromatography prompted the application of a similar technique to umbellulone.

A sample of the latter compound was prepared by fractional distillation from oil of Californian laurel, and was subjected to chromatography on an alumina column, using petroleum ether as developing solvent. Although the starting material was colourless, a faint yellow coloration (easily visible under ultra-violet light) developed in the column, and using this as guide, the extruded column was cut into portions, which were extracted by a mixture of petrol and alcohol. After removal of solvent, the fractions, consisting of oily material, amber in colour, and with a much less pronounced odour than the original oil, were examined spectroscopically. All gave the typical absorption spectrum of umbellulone, no significant variation in the ratio $\varepsilon(220)/\varepsilon(265)$ being observed. The intensity values found, however, were much lower than those of the starting material. On storing overnight in a vacuum desiccator, all except one of these fractions solidified to a mass of yellowish crystals. Recrystallization from petroleum ether yielded colourless crystals of an optically inactive substance, melting point 69° (found: C, 80; H, 9·8 per cent; $C_{10}H_{14}O$ requires: C, 80; H, 9·3 per cent), and gave the absorption spectrum shown in the graph ($\lambda\lambda_{max.}$(220) and 267 mμ, E(1%, 1 cm.) 233 and 107). The total yield of this substance, which was tentatively named ψ-umbellulone, was about 80 per cent of the starting material.



Absorption spectra of (*a*) umbellulone; (*b*) ψ-umbellulone; (*c*) 2,4-dinitrophenylhydrazone of umbellulone in chloroform; (*d*) 2,4-dinitrophenylhydrazone of ψ-umbellulone in chloroform

The chromatogram was repeated with development by ether and benzene respectively, elution in each case being by a mixture of alcohol and the developing solvent. Yields of ψ-umbellulone varying from 40 to 80 per cent were obtained, a pale yellow colour (brown under ultra-violet) appearing on the column in each case.

The 2,4-dinitrophenylhydrazones of both umbellulone and ψ-umbellulone were prepared. The former was slowly deposited from a mixture of umbellulone and Brady's reagent. Recrystallized from ethyl alcohol, in which it is appreciably soluble, it had a melting point of 134·5° (found: N, 16·9 per cent; $C_{16}H_{18}N_4O_4$ requires N, 16·9 per cent; in chloroform, $\lambda_{max.}$ 388 mμ, E(1%, 1 cm.) 888). The derivative of ψ-umbellulone was formed more readily, and in better yield. It was almost insoluble in ethyl alcohol. Recrystallized from chloroform, it had a melting point of 254–255° (decomp.) (found: N, 16·3 per cent; in chloroform, $\lambda_{max.}$ 379 mμ, E(1%, 1 cm.) 570). The absorption spectra of these two compounds are shown in the accompanying graph.

Hydrogenation products of both umbellulone and ψ-umbellulone were prepared by catalytic hydrogenation. β-Dihydroumbellulone was found to be, as described by previous workers, a mobile liquid

with a camphor-like smell. Examined spectroscopically, it had $\lambda\lambda_{max.}$ (220) and 280 mμ, $E(1\%, 1\ cm.)$ 36·3 and 3·7. ψ-Umbellulone took up 1·0 mole of hydrogen per molecular weight of umbellulone, and formed a substance which crystallized in silky needles of melting point 79°; $\lambda\lambda_{max.}$ (220) and 280 mμ, $E(1\%, 1\ cm.)$ 23·9 and 1·5.

The similarity of the absorption spectra of umbellulone and ψ-umbellulone points to the presence of the same chromophoric system in both compounds. Koch[7] showed that *cis-trans*-isomers characteristically give rise to absorption spectra with only slight differences in the location of the bands, but appreciable differences in the corresponding extinction coefficients. Inspection of structure (I), however, shows that isomerization of this type cannot occur. It is interesting that two different β-dihydroumbellulols have been reported in the literature, that prepared by Semmler[8] being a liquid with boiling point 88–92°/10 mm., while Weinhaus and Todenhofer (1929) obtained a crystalline solid of melting point 55–56°. The relationship of the two substances has not been elucidated.

The absorption spectrum of carone (II) has been reported by Klotz[9], who found $\lambda\lambda_{max.}$ (200) and 288 mμ, ε 2,700 and 34. If Semmler's structure for umbellulone is correct, a similarity in the absorption spectra of carone and β-dihydroumbellulone would be expected, and was in fact found, the *K*-band of the latter compound, however, having a lower intensity, measured at 220 mμ.

The investigations were interrupted by the death of Dr. Gillam and were incomplete.

All melting points are uncorrected. Absorption spectra were measured on a Hilger E_3 quartz spectrograph, with a Spekker photometer, and unless otherwise stated are in ethyl alcohol solution.

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Effect of Pyrophosphate on the Shortening of Muscle-Fibre Models in Presence of Adenosine Triphosphate

Weber[1] has shown that pyrophosphate in fairly high concentrations (20 m*M* or above) produces relaxation in single glycerinated muscle fibres which have shortened or developed tension in adenosine triphosphate. He found, however, that it had this effect only when adenosine triphosphate was absent, shortening proceeding normally in presence of the latter. This contrasts markedly with the lengthening effect of the so-called Marsh factor, which is a protein found in aqueous extracts of muscle[2,3]. The latter effect manifests itself only in the presence of adenosine triphosphate and magnesium chloride (2–8 m*M*) and is inhibited[3,4] by traces of calcium chloride (0·2 m*M*).

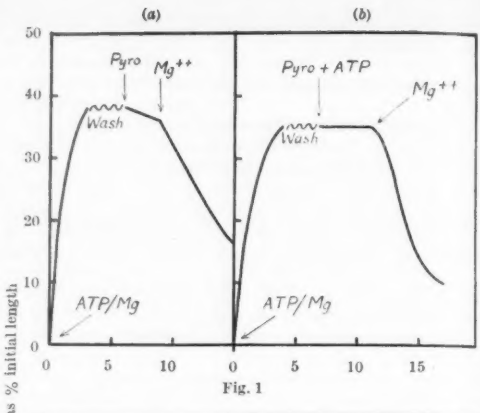

Fig. 1

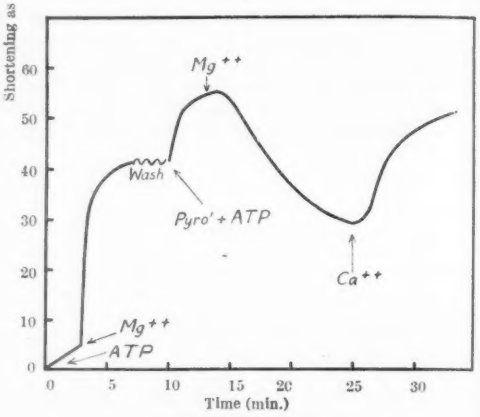

Fig. 2

Fig. 1. Effect of addition of 20 m*M* pyrophosphate to a muscle shortened under load in adenosine triphosphate/magnesium solution, (*a*) alone and (*b*) in the presence of 7 m*M* adenosine triphosphate, with and without magnesium chloride. ATP/Mg = 7 m*M* adenosine triphosphate + 4 m*M* magnesium chloride in 0·16 *M* potassium chloride; Pyro = addition of pyrophosphate to 20 m*M*; Pyro + ATP = addition of pyrophosphate to 20 m*M* and adenosine triphosphate to 7 m*M*; Mg^{++} = addition of magnesium chloride to 4 m*M*; Wash = wash for 10 min. in 0·16 *M* potassium chloride

Fig. 2. Effect of addition of 4 m*M* pyrophosphate and adenosine triphosphate to a shortened muscle, with and without magnesium chloride. Inhibition of lengthening by calcium chloride. Pyro' + ATP = addition of pyrophosphate to 4 m*M* and adenosine triphosphate to 7 m*M*; Ca^{++} = addition of calcium chloride to 0·2 m*M*. Other legends as in Fig. 1

In view of this, it was thought of interest to study the effect of magnesium and calcium ions and of adenosine triphosphate on lengthening in pyrophosphate. For this purpose glycerinated fibre-bundles, 0·35 mm. in diameter and 1·5–2·0 cm. long, were prepared by the method described by me[3]. They were loaded at 200–300 gm./sq. cm. and, after washing in 0·16*M* potassium chloride for 1 hr. to remove Marsh factor, shortened by at least 32 per cent of their initial length in the presence of 7 m*M* adenosine triphosphate + 4 m*M* magnesium chloride in 0·16 *M* potassium chloride (this solution is referred to as ATP/Mg). In the experiments which follow, all additions of substrates were made such that the final concentration of potassium chloride was 0·16 *M*.

The first experiment (Fig. 1,*a*) was designed to show the effect of 20 m*M* pyrophosphate (*p*H 7·0) on a muscle shortened previously by 38 per cent of

its initial length in ATP/Mg and then washed to remove magnesium ions. It is seen that the pyrophosphate brings about slow lengthening which is accelerated five-fold by addition of magnesium chloride to 4 m*M*. The second experiment (Fig. 1,*b*) shows the effect of addition of 20 m*M* pyrophosphate + 7 m*M* adenosine triphosphate to a similar muscle. In this case, the muscle remained at its shortened length until magnesium chloride was added to 4 m*M*, when rapid lengthening set in. Thus magnesium chloride drastically modifies the effect of pyrophosphate with or without addition of adenosine triphosphate, and stimulates lengthening in both cases. The effect of the magnesium ion here is the opposite of its effect in the absence of pyrophosphate, when it markedly accelerates shortening, as seen at the beginning of the third experiment (Fig. 2). This experiment also illustrates the effect of adding pyrophosphate at 4 m*M*, that is, one-fifth the concentration employed by Weber. Here 7 m*M* adenosine triphosphate + 4 m*M* pyrophosphate brought about shortening which was rapidly reversed by addition of magnesium chloride to 4 m*M*. This lengthening was, however, immediately inhibited and shortening once more accelerated by addition of calcium chloride to 0·2 m*M*. In this connexion, it should be noted that calcium chloride in these low concentrations does not stimulate shortening in the absence of magnesium chloride, nor in its presence alone, but does so only when lengthening in pyrophosphate or Marsh factor has occurred.

Fig. 3 shows the effect of pyrophosphate concentration on the rate of lengthening (*a*) by itself, (*b*) in the presence of 4 m*M* magnesium chloride, and (*c*) in the presence of 4 m*M* magnesium chloride and 7 m*M* adenosine triphosphate. It is seen that lengthening occurs at pyrophosphate concentrations as low as 1 m*M* when the magnesium ion is present, whereas in its absence lengthening is not detectable at even 4 m*M* pyrophosphate. The addition of adenosine triphosphate as well as magnesium chloride further enhances the effect, although adenosine triphosphate in the absence of magnesium chloride brings about little or no change of length.

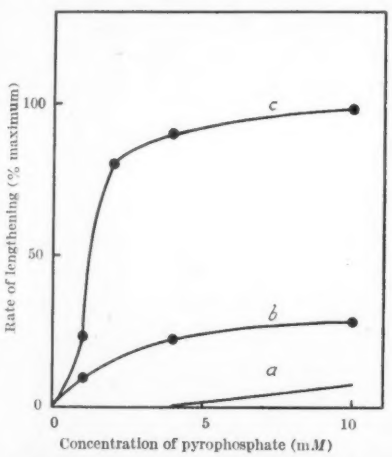

Fig. 3. Effect of pyrophosphate concentration on the rate of lengthening (*a*) by itself, (*b*) with 4 m*M* magnesium chloride, (*c*) with 4 m*M* magnesium chloride and 7 m*M* adenosine triphosphate. The rate is expressed as the percentage of the rate in 20 m*M* pyrophosphate per 4 m*M* magnesium chloride per 7 m*M* adenosine triphosphate (that is, the maximum value)

Thus, the effect of magnesium chloride on lengthening in pyrophosphate is strikingly similar to its effect when the Marsh factor is present. A further similarity is the effect of low concentrations of calcium chloride (0·2 m*M*) which reverses lengthening in both cases. It is not suggested, however, that pyrophosphate plays any part in the Marsh effect, but rather that, where lengthening is concerned, certain ionic conditions are common and necessary to whatever agent may be used to initiate it, and that, in particular, the presence of the magnesium ion (2–8 m*M*) is essential.

The work described in this paper was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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Glycerophosphoryl Choline as a Precursor of Free Choline in Mammalian Semen

In earlier studies it has been shown[1,2] that the very considerable concentration of choline in human semen (200–300 mgm./100 gm.) arises through the enzymatic hydrolysis by the prostate phosphatase of phosphoryl choline formed in the vesicular glands. In continuation of this investigation a method was worked out for the quantitative estimation of phosphoryl choline in tissue samples[3]. Choline is determined before and after treatment with phosphomonoesterase under optimal conditions. Purified prostate phosphatase is very useful for this purpose as it displays no activity towards secondary phosphate esters. On samples of tissue weighing 0·5 gm. it is possible to estimate amounts of phosphoryl choline corresponding to 10 mgm. choline chloride per 100 gm. of tissue with reasonable accuracy (± 5 per cent).

Analyses of accessory sex glands from the rat, guinea pig and rabbit revealed definitely the presence of phosphoryl choline in some of the glands (see accompanying table). When, however, a saline extract from the ventral prostate of the rat was mixed with extracts from the seminal vesicles or the dorsal prostate and incubated at 37° C. for one hour, much larger amounts of free choline were liberated than could be accounted for as phosphoryl choline, indicating the presence of some other precursor. Application of the method of Schmidt *et al.*[4] for estimating glycerophosphoryl choline revealed in the vesicular gland and the dorsal prostate of the rat a high concentration of a secondary choline phosphate ester, presumably glycerophosphoryl choline. The figure found for the seminal vesicle of the guinea pig is in good agreement with the figure of Kahane and Lévy[5] for total water-soluble choline.

The following procedure was employed in an attempt to identify the substance. A trichloracetic acid extract of vesicular glands from a number (4–8) of rats was extracted with ethyl ether three times, neutralized, and precipitated with barium acetate plus four volumes of ethanol. The clear alcoholic

Water-soluble Choline Compounds in some Accessory Sex Glands expressed as mgm. Choline Chloride per 100 gm. of Moist Tissue

	Free choline	Phosphoryl choline	Glycero-phosphoryl choline
Rat (5 experiments)			
Vesicular glands	1–3	19–24	207–305
Dorsal prostate	2·5–9	8–13	56–98
Guinea pig (3 experiments)			
Vesicular glands	9–16	4	70
'Prostate'	2–5·5	2–6	0–12
Rabbit (1 experiment)			
Vesicular gland	1·4	2·8	49
'Prostate'	4	?	18

solution obtained after centrifugation was concentrated *in vacuo*, and barium removed as sulphate. The resulting solution showed a ratio of 1 : 1 between total phosphorus and 'bound choline'. 'Bound choline' was calculated as the sum of choline liberated by phosphatase and easily hydrolysable choline, which is liberated in 20 min. at 100° C. in *N* HCl. Treatment under these conditions for forty minutes does not increase the amount of choline formed. In alcoholic solution the substance gives a precipitate with cadmium chloride just like glycerophosphoryl choline.

After acid hydrolysis for 20 min. all the phosphorus is recovered in the fraction of barium salts soluble in water but insoluble in alcohol, and can be transformed quantitatively into inorganic phosphorus through the action of prostate phosphatase. This primary ester on treatment with periodic acid[6] behaves as a mixture of alpha and beta glycerophosphate. The acid treatment has possibly caused some alpha–beta migration[7].

The glycerophosphoryl choline is predominantly formed in the vesicular glands in the three species investigated and is apparently split very readily by an enzyme from the other accessory sex glands, especially the ventral prostate (rat) with liberation of choline. The formation of this substance appears to be under hormonal control as the level (on a moist tissue basis) drops to about 5 per cent of the normal level after castration (two months). The fact that choline is formed by different routes in semen of various animals certainly suggests that this substance is of importance in the reproductive process. The study of this problem is in progress.

This investigation has been aided by grants from the Jane Coffin Childs Memorial Fund for Medical Research, and Kong Christian den Tiendes Fond. It is hoped to publish a full report shortly.

Note. After this communication was submitted for publication a note by Diament, Kahane and Lévy[8] has come to my notice, in which the identification of glycerophosphoryl choline in rat seminal vesicles was performed as a ferric chloride complex.

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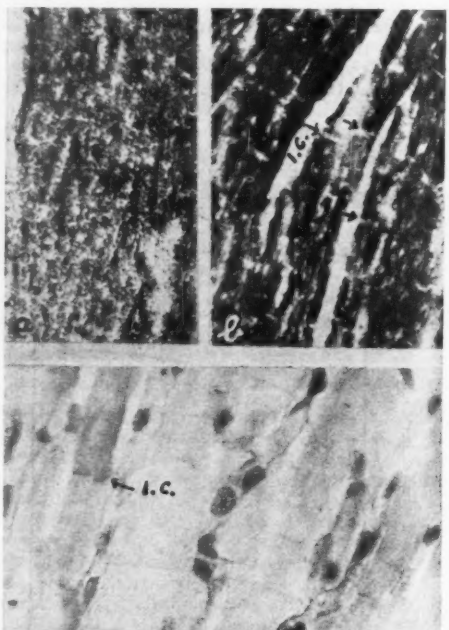
Enzymes of the Intercalated Disks of Heart Muscle Fibres

Heart muscle fibres are interrupted periodically by basophilic structures known as intercalated disks. They are stated not to occur in human fœtal heart muscle ; but they have been recorded in that of other fœtal mammals[1,2] and of new-born humans[3]. Some of these authors claim that the disks increase in number with age. The function of these disks is undecided ; they are invariably associated with the *Z*-band, and it is certain now that they are not, as was first thought, histological artefacts. They appear to be made up of parallel rods which are continuous at either end with the myofibrils. Among the suggestions made for their function (see Cohn, 1932 [4]) are that they may represent growing-points of cardiac muscle or that they may represent tendinous regions. There is no real evidence to support either of these suggestions.

When histochemical tests for succinic dehydrogenase are applied to heart muscle of the rat using the method described originally by Seligman and Rutenberg[5], but using neotetrazolium instead of blue tetrazolium as recommended by Shelton and Schneider[6], it can be seen that the intercalated disks show a positive reaction, thus indicating that they possess considerable metabolic activity. However, this reaction is a little less than that of the rest of the muscle fibre, so that in such preparations the disks can be distinguished but in most cases only with difficulty (Fig. *a*). However, if the succinic dehydrogenase reaction is applied to



(*a*) Succinic dehydrogenase reaction in normal rat heart muscle. Intercalated disks cannot be distinguished. (× 380.) (*b*) Succinic dehydrogenase reaction in heart muscle of normal rat treated with cortisone. Note intensification of reaction in fibres but negative reaction in intercalated disks. (× 380.) (*c*) Localization of enzyme hydrolysing riboflavin phosphate in intercalated disks and capillary endothelial nuclei in heart muscle of normal rat. (× 400)

the heart muscle of rats which have been treated with cortisone, or deoxycorticosterone, the reaction in the muscle fibres is found to be increased but that of the intercalated disks to have become completely negative (Fig. *b*). Adrenalectomy results in a loss of activity from the fibres and disks, and treatment with cortisone restores the reaction completely in the fibres but the reaction is still negative in the disks. (Full details of this work are to be published elsewhere[7].)

Histochemical tests for phosphatases have also been carried out on heart muscle using modifications of the method first described by Gomori[8]. Non-specific alkaline phosphatase (using glycerophosphate as a substrate at *p*H 9·0) was found to be localized in the capillary vessels and in all the intercalated disks. Using a variety of sugar phosphates (which are also split by non-specific phosphatase) the same result was obtained. Adrenalectomy caused reduction of the phosphatase reaction in the intercalated disks but not in the capillaries. Injection of cortisone into intact animals had little effect.

Using riboflavin phosphate as a substrate (at *p*H 9·0) scarcely any reaction was given by the capillaries or by the muscle fibres; but the intercalated disks were positive (Fig. *c*). With pyridoxal phosphate as a substrate the disks give a less-marked reaction than the fibres and some were completely negative. (This negative reaction, incidentally, suggests that the positive reaction given by the disks with other phosphate substrates was not due to an affinity by the disks for the reaction product, calcium phosphate.)

When riboflavin phosphate and pyridoxal phosphate were used as substrates in an acid medium (*p*H 5·0) heart muscle was completely negative with the former; but with the latter the sarcosomes gave a positive reaction, and in the intercalated disks there was a central very thin positive region surrounded on either side by a negative region.

I am indebted to Dr. H. A. Malaty for permission to refer to joint experiments on succinic dehydrogenase still in the press, and to Dr. A. L. Morrison director of research, Roche Products, Ltd., for a supply of vitamin phosphates.

Note added in proof, August 31. Dephosphorylating enzymes are frequently found in cellular sites where the production of free energy is necessary (for example, brush borders of absorbing cells), and the localization of these enzymes in the intercalated disks suggests that they may likewise be regions where release of energy takes place. Heart muscle fibres are not individually innervated as are those of skeletal muscle, and the contraction wave must spread from the regions of innervation through the cardiac syncytium. Because of the presence of dephosphorylating enzymes in the intercalated disks, it seems possible that the latter may act as boosters of this contraction wave. It is of interest that specific choline esterase preparations prepared according to the method of Ravin *et al.*[9] show, as did their preparations, that this enzyme is distributed in granular form throughout the cardiac muscle fibres and is not localized in the intercalated disks.

The effect of adrenalectomy on the enzyme reactions is not unexpected, but the effect of injection of cortisone and deoxycorticosterone into intact animals on the succinic dehydrogenase reaction of the disks, is difficult to explain. That this negative reaction by the disks may be a normal 'stress' effect is suggested by the fact that it was obtained in the heart muscle (obtained within an hour of death) of a man subjected to great and prolonged emotional strain prior to death.

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Mode of Action of Beryllium on Alkaline Phosphatase

RECENTLY, Klemperer *et al.*[1] and Grier *et al.*[2] demonstrated the inhibitory effect of low concentrations of beryllium salts on alkaline phosphatase *in vitro*. This action was found to be rather specific[3] and we hoped to be able to shed new light on the old controversy concerning intestinal sugar absorption[4,5] and the role of alkaline phosphatase. Into isolated parts of the rat's small intestine, left *in situ*, we introduced solutions of glucose with or without added beryllium sulphate. There was no difference in the rate of absorption of glucose. Any conclusion from these experiments, however, is dependent on whether the phosphatase is inhibited *in vivo* as it is *in vitro*. Klemperer[3] suggested that interference with phosphatase action is related to the toxicity of beryllium. This would include an action on phosphatase *in vivo*. It seemed necessary, however, to obtain more conclusive evidence about this problem, especially about the mode of action of beryllium salts on alkaline phosphatase. Klemperer *et al.*[1] and Grier *et al.*[2] considered the possibility that, owing to the amphoteric properties of beryllium hydroxide, beryllate ions might be the inhibiting agent at the *p*H of optimal enzyme activity. We confirmed the observation of the first-named authors that the relative inhibition increases with increasing *p*H, reaching a constant high value at the *p*H of optimal enzyme activity; but we must agree with them that no conclusion can be drawn therefrom as to the form in which beryllium is active as an inhibitor. Treadwell and Boner[6], however, clearly demonstrated that beryllate ions do not exist at a *p*H lower than 12·5. At the *p*H of optimal enzyme activity (9·6) practically all the beryllium will be in the form of precipitated (colloidal) beryllium hydroxide.

We investigated the mode of action of beryllium in the following way. Phosphatase activity was determined by a modification (unpublished) of the method of Kroon *et al.*[7]. The reaction mixture consisted of 0·5 ml. buffer (barbital–hydrogen chloride), 0·1 ml. enzyme solution (normal tissue extracts as well as dialysed (phosphate-free) and purified enzyme solutions were used), 0·1 ml. substrate solution (= 4 mgm. sodium-β-glycerophosphate), 0·1 ml. water or beryllium chloride solution 8×10^{-4} *M*, final *p*H 9·6.

Experiments 1 and 2 in the accompanying table are, respectively, a control and a determination of the normal inhibition. Experiment 3 shows that the inhibiting form of beryllium is eliminated by filtration. This is not caused by adsorption on the filter

No.	Experiment	μgm. P liberated in 1 hr. at 37° C.	Inhibition (per cent)
1	Enzyme + buffer + water + substrate } incubated	14·2	—
2	Enzyme + buffer + $BeCl_2$ + substrate } incubated	2·1	83
3	Buffer + $BeCl_2$ } filtered ↓ filtrate + enzyme + substrate } incubated	14·0	1
4	Buffer + $BeCl_2$ } shaken with filter paper and decanted ↓ decantate + enzyme + substrate } incubated	2·8	80
5	Buffer + $BeCl_2$ + substrate } filtered filtrate + enzyme } incubated	13·9	2
6	Buffer + $BeCl_2$ + substrate } filtered ↓ filtrate + substrate } incubated	2·3	84

paper, as shown in experiment 4. Obviously the inhibition must be ascribed to the beryllium hydroxide precipitate. Experiments 5 and 6 differentiate between the following two possibilities: (*a*) influence on the substrate, for example, by adsorption in inaccessible form; (*b*) influence on the enzyme. This leads to the conclusion that the inhibition of alkaline phosphatase *in vitro* is caused by interaction between precipitated beryllium hydroxide and the enzyme, perhaps by co-precipitation. Under the experimental conditions described, the precipitate is not visible in the reaction mixture or on the filter paper. It can be made visible by addition of an alizarin dye, for example, alizarin bordeaux. After filtration a small amount of a coloured precipitate is visible on the paper.

In our opinion, the inhibition *in vitro*, as described above, bears no relation to the action of beryllium *in vivo*, notwithstanding the suggestion to the contrary by the development of rickets-like bone lesions on administration of beryllium salts to rats. Klemperer[3] ascribes the activation of succinic oxidase by beryllium to an alteration of the colloidal structure of the enzyme caused by the gelatinous precipitate of beryllium hydroxide. He states that this activation appears to be unspecific and of little toxicological significance. On the same grounds, in our opinion, the *in vitro* inhibition of alkaline phosphatase appears to be unrelated to beryllium rickets and other manifestations caused by beryllium *in vivo*.

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Delayed Implantation in the Elephant Seal

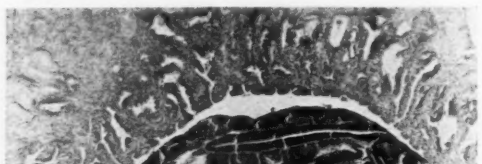
Since 1950, efforts have been made by biologists of the Australian National Antarctic Research Expedition at Heard Island to collect material for the study of the embryology of the elephant seal, *Macrorhinus proboscideus* (Peron and Lesueur). The task was rendered difficult by the fact that the female spends most of the year feeding at sea and only returns to land for parturition and moulting.

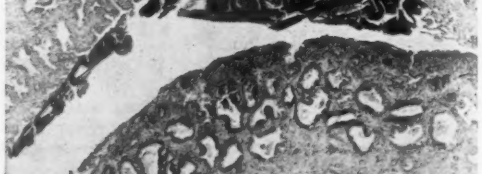
Copulation occurs during the last half of October and the first half of November, so that when harem cows come ashore to moult (between late December and late February), they must be from one to four months pregnant. It was thought that, by killing cows during the moulting season, a series of early fœtuses would be obtained.

Females were therefore killed throughout December 1952 and January and early February 1953; but although in almost every case a well-developed corpus luteum was found in one ovary, no sign of an embryo or of an area of implantation could be discovered in the uterus.

However, in late February and the first days of March 1953 five females were killed and in each case the lumen of the uterus was enlarged at one point to form a sort of pouch filled with a watery fluid. The mucosa in these areas appeared highly vascular; but microscopic examination failed to discover a fœtus.

The uteri were brought back to Australia and one 'pouch' sectioned. A 1·5-mm. embryo was found lying between folds of the uterine mucosa (Fig. 1). Very little chorionic tissue has so far been found, and in the sections so far examined only remnants





of fœtal membranes were located, indicating that the embryo may have been torn from its original implantation site when the uterus was first opened. The embryo was at the equivalent stage of development of a human embryo of about three weeks. Forebrain, nerve cord and ten somites are readily identifiable.

It was thought probable on the above evidence that in the elephant seal there is a delayed implantation such as occurs in the European badger, the American marten, the armadillo, the northern fur seal and other species. In such animals the egg develops to the blastocyst stage and then lies dormant, sometimes for months, before becoming implanted and continuing to develop.

Confirmatory evidence was discovered when the uterus of a seal killed in mid-December was sectioned and a 0·3-mm. blastocyst was found (Fig. 2). The blastocyst was enclosed in what appeared to be the much-thickened egg membrane, which was closely applied and probably attached to the uterine mucosa. No sign of implantation was observed.

Further sectioning of elephant seal uteri taken at different times in the moulting season is now being carried out in the hope of discovering more about the early embryology. A detailed account of these findings together with other information on the sexual cycle of the elephant seal will be included in a paper now in preparation.

L. Gibbney

Biology Section,
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June 4.

Varietal Reaction of Jowar to Grain Smut

Jowar (*Sorghum vulgare*, L.), an important grain crop, occupies about 23 lakh acres in Uttar Pradesh, and the State stands third in its production in India. The crop is invariably attacked by a severe smut disease caused by *Sphacelotheca sorghi* (Link) Clinton. It causes usually 2–5 per cent infection in the crop; but as high as 65 per cent infection has been recorded in some fields. On the basis of 2 per cent loss, the grain smut is responsible for a loss of more than five thousand tons of grain or 15·5 lakhs of rupees in terms of money annually. Considerable work has been done in Bombay and Uttar Pradesh as well as in other States of India on the control of the smut by fungicidal seed treatments; but there seems to be no report available on the resistant varieties of jowar to grain smut in India. The work on testing some varieties of jowar against grain smut was therefore started in 1950 and continued up to 1952.

Twenty-seven promising varieties or cultures of jowar were tested for their resistance towards grain smut. The seeds of the varieties or cultures were first moistened with water and then thoroughly mixed with smut spores (mixed collection from all over the United Provinces) in the proportion of 1 : 100 and were sown on three different dates at fortnightly intervals to give varying conditions of environment. The percentage of smut was calculated by counting healthy and smutted heads in each variety or culture. They can be grouped as follows, according to average smut infection shown by them.

Resistant (Below 1 per cent infection)	31*B*, 4101
Moderately resistant (Below 5 per cent infection)	4403, 4404*A*, *S.A.*7005, 4801(*a*), 4403*B*
Susceptible (Below 15 per cent infection)	30*D*, 4108, 10*E.K.*, 4404*B*, *S.A.*5155–5, 4801, 48/2, 4801(*b*), 4404*B-A*, 51/3
Very susceptible (Above 15 per cent infection)	5*T*, 8*B*, 30*C*, 18, 4106*B*, 4109, 9*E.K.*, 48/11, 48/10(*b*), 51/4.

Most of the very susceptible varieties showed 30–65 per cent infection.

It is evident from the results that the most popular varieties of jowar in the State, namely, 8*B* and 5*T*, are highly susceptible. The two cultures 31*B* and 4101 proved to be highly resistant. Five cultures proved moderately susceptible. This information may prove useful in evolving varieties of jowar by combining desirable grain characters with resistance to grain smut.

We are grateful to Dr. T. R. Mehta, economic botanist (oilseeds, millets and pulses) to the Government, United Provinces, Kanpur, for the supply of jowar varieties and cultures employed during the investigation.

P. R. Mehta
Babu Singh
S. C. Mathur
S. B. Singh

Laboratory of Plant Pathologist to the
Government of the United Provinces,
Kanpur.
May 20.

Chromosomes of *Phylloglossum drummondii*, Kunze

Phylloglossum, the monotypic genus of the Lycopodiaceæ, is confined to Australia and New Zealand, being represented by the single species, *Phylloglossum drummondii*. Much attention has been given to the morphology and anatomy of the plant over the past fifty years by Bower, Thomas, Osborn and other workers, and there has been much speculation on the evolutionary interpretation of its structure. A comprehensive review of all this work has been given, recently, by Hackney[1]; but at no time has the cytology of the plant been discussed.

Manton[2] deals in detail with the cytology of the lycopods of Europe only, and so does not include a study of the chromosomes of *Phylloglossum*.

It seems fitting, then, to record the chromosome number and arrangement in *Phylloglossum drummondii* observed in material collected at Heathmont, Victoria, in 1952. The stroboli were fixed in acetic-alcohol and preparations made by using the iron–aceto-carmine squash technique.

Fig. 1 shows a metaphase plate of the first meiotic division in polar view with 246 bivalents and 10 univalents, giving a diploid number of 502. Fig. 2 is a camera lucida drawing of Fig. 1. With such a large number it is difficult to obtain the necessary 'spread' of the chromosomes to be certain of the count; but, allowing for a good margin of error in observation, the haploid number is not less than 250 and not more than 255. The presence of univalents (marked *a* in Fig. 2 was verified by observations of unpaired chromosomes at the pachytene stage of meiosis.

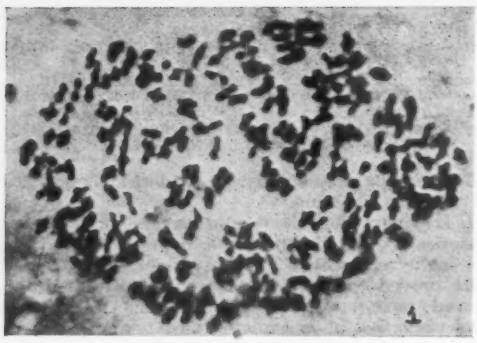

Fig. 1. Metaphase I; permanent aceto-carmine. (× 1,350)

Fig. 2. Camera lucida drawing of Fig. 1, with univalents marked *a*. (× *c.* 1,560)

Manton, in discussing the chromosome number of *Lycopodium selago*, which has 113 bivalents and 37 univalents, suggests that the actual number is not as significant as the presence of univalents. These are an indication of irregular pairing and point to a possible hybrid origin. What the hybrid origin of *Phylloglossum* could be, with its restricted distribution and absence of related types, is a matter for speculation. In the possession of univalents *Phylloglossum drummondii* resembles *Lycopodium selago* more than the other lycopods studied by Manton.

Considering the number of chromosomes, however, *Phylloglossum drummondii*, with $2n = c.$ 502–510, is similar to the primitive fern *Ophioglossum vulgatum*, with a diploid number of *c.* 500–520. Both would appear to have a chromosome number higher than any yet found in a wild plant species.

It is hoped to complete a study of meiosis in *Phylloglossum drummondii* when more fresh material becomes available.

My thanks are due to Dr. E. I. McLennan for material and Dr. I. C. Cookson for help with photography.

M. Blackwood

Botany School,
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June 25.

Chromosome Numbers in the Desmids

The following chromosome counts have been made on culture material of the Desmidiaceæ:

	Closterium lleibleinii Kütz.	$n =$ 66
612/1	*Cosmarium botrytis* Meregh.	$n =$ 26
	C. botrytis	$n =$ 18
612/5	*C. botrytis* (*forma* ?)	$n =$ *c.* 94
612/10	*C. cucumis* (Corda.) Ralfs.	$n =$ 44 and $n =$ 52
612/3	*C. margaritiferum* (Turp.) Menegh.	$n =$ *c.* 64
612/8*a*	*C. subtumidum* Nordst.	$n =$ 24
637/1	*Hyalotheca dissiliens* (Sm.) Breb.	$n =$ *c.* 112
652/1	*Netrium digitus* (Ehrenb.) Itzigs. and Rothe.	$n =$ 592
664/2	*Pleurotænium trabecula* (Ehrenb.) Naeg.	$n =$ 104

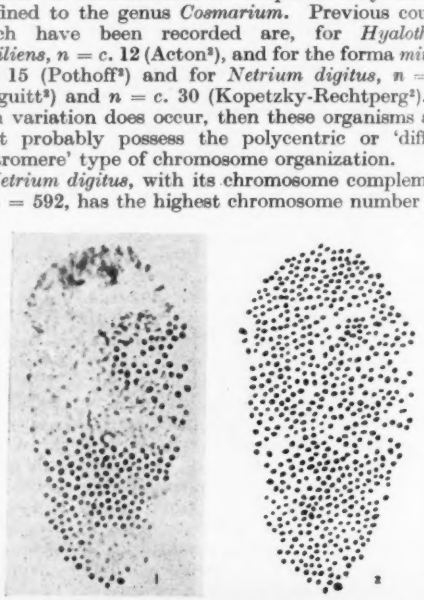
The majority of these cultures were obtained from the Cambridge Culture Collection of Algæ and Protozoa. The numbers preceding cultures from this source are those designated in that collection.

The count of $n = 18$ for *Cosmarium botrytis* has been previously published by me[1], but is included here for comparison. Similarly for *Pleurotænium trabecula*, which I previously published under the erroneous name of *P. kallis*.

No morphological differences can be found between the $n = 18$ and the $n = 26$ clones of *C. botrytis*, nor between the $n = 44$ and $n = 52$ groups within the single clone of *C. cucumis*. The variation in the chromosome number in these species does not, therefore, appear to be due to polyploidy, but rather to the processes of fragmentation and/or fusion of chromosomes. For the former process to result in a transmissible increase in the number of chromosomes, a polycentric or 'diffuse centromere' type of chromosome organization must be present. Such an organization would be a concomitant of the process of fusion. Cytological confirmation that one or other of these types of chromosome organization exists in these two organisms has been obtained (that for *C. botrytis* having been previously published).

Comparison between the present counts and those of previous authors indicates that variation in the number of chromosomes in a species may not be confined to the genus *Cosmarium*. Previous counts which have been recorded are, for *Hyalotheca dissiliens*, $n = c.$ 12 (Acton[2]), and for the forma *minor*, $n = 15$ (Pothoff[2]) and for *Netrium digitus*, $n = 32$ (Maguitt[2]) and $n = c.$ 30 (Kopetzky-Rechtperg[2]). If such variation does occur, then these organisms also most probably possess the polycentric or 'diffuse centromere' type of chromosome organization.

Netrium digitus, with its chromosome complement of $n = 592$, has the highest chromosome number yet



Figs. 1 and 2. Mitotic metaphase plate of *Netrium digitus*, $n = 592$. Fig. 2 was constructed from six photomicrographs taken at different focal levels. × 1,250

[1] Hackney, Frances M. V., *Proc. Linn. Soc. N.S.W.*, **75**, 133 (1950).
[2] Manton, I., "Problems of Cytology and Evolution in the Pteridophyta" (1950).

recorded in the plant kingdom, the previous highest being that recorded by Manton[3] for *Ophioglossum vulgatum* (n = 250–260).

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May 4.

[1] King, G. C., *Nature*, **171**, 181 (1953).
[2] See Kreiger, W., "Die Desmidiaceen—Rabenhorst Kryptogamen-Flora", 13.
[3] Manton, I., "Problems of Cytology and Evolution in the Pteridophyta" (Cambridge, 1950).

Relation between Dye Uptake and Cytoplasmic Streaming in *Amœba proteus*

Goldacre[1] has recently proposed a theory of osmotic work which is based, in part, on the manner in which streaming amœbæ accumulate vital dyes. Goldacre reported that streaming *Amœba discoides*, when placed in dilute solutions of neutral red, methylene blue, or brilliant green, accumulated the dye in the tail. Non-streaming amœbæ became stained only at the periphery. The experiments were repeated in this laboratory using *Amœba proteus*. The observations in general confirmed those reported by Goldacre, and further experiments employing hydrostatic pressure lend support to his interpretation.

Neutral red (0·005 per cent solution) and methylene blue (0·010 per cent solution) appeared first in the tail of streaming *A. proteus*; but in each case the dye was soon distributed throughout the cytoplasm in small vacuoles which eventually became coloured intensely red or blue. After 48 hr. in neutral red solution, the cytoplasm had a general pink tinge colour in addition to the intense accumulation of dye in the small vacuoles. The nucleus remained unstained. The amœbæ seen with the naked eye stand out as bright red spots. In a 0·002 per cent solution of brilliant green, amœbæ immediately ceased streaming and within a few hours underwent cytolysis.

The effect could be emphasized even more if amœbæ were kept at 12° C. for some hours. At such a low temperature most of the amœbæ became monopodal in form and streamed very weakly. Brought to room temperature (22° C.) in 0·005 per cent neutral red solution over a period of 3–4 min., the amœbæ began streaming more rapidly than controls and with a very marked accumulation of dye in the tail. The dye was soon distributed throughout the amœbæ by the moving plasmasol. Once the dye has been distributed, the colour contrast is insufficient to allow detection of any slightly higher concentration of dye in the tail.

If the dye uptake is causally related to streaming, amœbæ subjected to hydrostatic pressure sufficient to prevent streaming should also fail to accumulate dye. Amœbæ were placed in a 0·005 per cent neutral red solution and kept under a pressure of 425 atmospheres for 30 min. With this treatment the amœbæ rounded up, and the surface membrane could be distinguished as a blurred red line (in optical cross-section). No dye was detectable in the cytoplasm. The amœbæ thus treated did not resume streaming until 30–60 min. after release of the pressure. A second group of amœbæ was placed in 0·005 per cent neutral red solution and subjected to a pressure of 350 atmospheres for 30 min. Again the amœbæ rounded up, with a visible accumulation of dye on the surface; but within 60 sec. after release of the pressure they began streaming even more vigorously than the controls. When the amœbæ had moved a distance equal to but a fraction of their lengths, the surface membrane was no longer visibly 'stained', and dye was now clearly visible in the tail. With continued streaming the dye could be seen to be carried forward and distributed throughout the cytoplasm by the plasmasol.

The pressure experiment is of particular interest because it not only relates the dye uptake to visible streaming but also to unfolding of protein molecules, according to Eyring, Johnson and Gensler's interpretation of pressure effects on proteins[2].

In neutral red staining it was noticed that the tail of the amœba was slightly acid relative to the rest of the cytoplasm.

Finally, it should be emphasized that the observation of the accumulation of dye at the tail requires considerable time and patience; the effect will not be detected by the casual observer.

I wish to thank Dr. Daniel Mazia for his direction of this work.

D. M. Prescott

Department of Zoology,
University of California,
Berkeley, California.
March 28.

[1] Goldacre, R. J., *Int. Rev. Cyt.*, 1, 135 (1952). Goldacre, R. J., and Lorch, I. J., *Nature*, **166**, 497 (1950).
[2] Eyring, H., Johnson, F., and Gensler, R., *J. Phys. Chem.*, **50**, 453 (1946).

Prescott's confirmation and extension of the results of Lorch and myself suggest the following comments:

(1) While the accumulation of neutral red in the tail of the amœba must often have been overlooked by the casual observer, it can readily be made visible by sucking away most of the dye solution in the hanging drop with a fine pipette, which improves the contrast. Better still, if the streaming of the amœba is inhibited by too high a concentration of dye, it can be restored by replacing the dye solution with culture medium, when the dye which has been adsorbed by the cortical gel over the whole surface of the amœba is completely released into the tail when the amœba has moved a distance equal to its own length.

Prof. J. F. Danielli informs me that students at King's College, London, have now regularly seen this phenomenon in a class experiment using *A. proteus*, which we have found behaves similarly to *A. discoides* in this respect.

(2) The slight acidity in the tail of the amœba reported by Prescott has sometimes been suggested as the cause of the accumulation of the partly ionized dye. Mere passive diffusion of the un-ionized molecular species through the membrane, to ionize again inside according to its ionization constant and the *p*H, would result in a higher concentration of the dye ion in the more acid region at equilibrium. However, experiment suggests that this difference in colour of the indicator between the tail and the cortical gel is not necessarily due to a change in *p*H, but to a change in the protein error of the indicator when the protein molecules fold up. It was found that when serum albumin, in a solution strongly buffered at *p*H 7 and containing a trace of indicator, was heated

on a water-bath and cooled to its original temperature, the colour of the indicator was different from that of the unheated control[1]. The glass electrode showed no change in *p*H, yet the apparent *p*H shown by the indicator had changed by about one unit. Unfolding of the serum albumin molecule was sufficient to reverse the sign of the protein error with phenol red. If protein molecules fold up in the tail as postulated by Goldacre and Lorch, it would be surprising on chemical grounds if there was no change in protein error and in apparent *p*H as measured with indicators.

Moreover, accumulation of neutral red was found to occur in *A. proteus* from solutions at *p*H 4, 5, 6, 7 and 8 (0·02 per cent dye with *M*/200 acetate and phosphate buffers checked by glass electrode), which could not occur if it depended only on passive diffusion between regions of slightly different *p*H inside and outside the amœba.

(3) The difference in colour of the neutral red indicator between the front and back of the amœba is at least partly an optical artefact due to the difference in concentration of the dye. It is impossible to compare *p*H values unless the concentration of the indicator is the same. Neutral red solutions in buffer at *p*H 8 appeared red when the dye concentration was high, and yellow when the concentration was low; also, the same dense neutral red solution at *p*H 8 placed in a tapering centrifuge tube appeared yellow at the narrow end and red at the wide end. A familiar example of a similar effect occurs in blood, the red cells of which appear yellow when viewed as individuals under the microscope. This dichroism has been explained by Wright[2] in terms of the properties of the Beer–Lambert law. Any indicator in its useful *p*H range has an unsymmetrical absorption curve, due to the presence of the two molecular species, and under these conditions the ratio of the transmitted light at two different wave-lengths is not constant, but changes with the concentration and the thickness of the solution; for the transmitted light is not proportional to the dilution, but to the anti-logarithm of the dilution, as indicated by the Beer–Lambert law, $I/I_0 = \exp(-kdC)$. Thus a change in concentration or thickness can simulate a change in *p*H.

Effects (2) and (3) above, working together under varying conditions, may account for the conflicting reports on the variation in *p*H at different parts of the amœba (see also refs. in footnote 3).

R. J. Goldacre

Chester Beatty Research Institute,
London, S.W.3.

[1] Goldacre, R. J., Ph.D. thesis, University of London (1952).
[2] Wright, D. W., *Nature*, **153**, 9 (1944).
[3] Pantin, C. F. A., *J. Mar. Biol. Assoc. U.K.*, **13**, 24 (1923). Chambers, R., *Biol. Rev.*, **24**, 246 (1949). Mast, S. O., *J. Morph. and Physiol.*, **41**, 347 (1926).

"Statistical Significance in Psychical Research"

We think it is important that readers of *Nature* should not be led by Mr. Spencer Brown's article on "Statistical Significance in Psychical Research" (*Nature*, July 25, p. 154) to think that there is ground for doubting the validity of the experimental work of the past twenty years in establishing the reality of phenomena commonly referred to as extra-sensory perception.

Mr. Brown says that, in demonstrations of telepathy, adequate control series have not been used and that control series would give equally curious results. The obvious and adequate control is to check series of guesses against packs of cards for which they were not intended. In many of the major experiments extensive checks of this kind have been made and the results have conformed to chance expectation. This seems to confirm the validity of the expectations on which the ordinary calculus of significance tests is based.

The thought in the paragraphs claiming to show that success in psychokinesis experiments assumes a contradiction certainly shows a confusion; but the confusion is Mr. Brown's. He seems to think that the applicability of significance tests to these experiments depends on the assumption that the dice throws form a random series. However, the question at issue is not whether the dice throws are random, but whether or not there is correspondence between the dice throws and the target numbers which have been randomly chosen.

Mr. Brown's experimental results on matching selected columns of random numbers may prove to be of interest to psychical research. But whether this is so or not can only be judged when these results, published with full details, have been criticized, and (if possible) confirmed by other workers. We cannot accept his inference that these results invalidate the conclusions drawn from experiments in extra-sensory perception.

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F. J. M. Stratton

Gonville and Caius College,
Cambridge.

R. H. Thouless

Corpus Christi College,
Cambridge.

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(1) The issue on which I chose to argue[1] was clearly stated in my first paragraph. Taking the psychical research data (that is, the residuum when fraud and incompetence are excluded), I tried to show that these now threw more doubt upon existing presuppositions in the theory of *probability* than in the theory of *communication*. Thus, though not doubting the validity of some of the experimental work by accepted standards, I was led to question the validity of one of the accepted standards.

(2) I do not say that control series in psychical research merely *would* give statistically significant results; I say, more strongly, that they frequently do[2].

What have been called control series in some experiments have been made up by subsequent re-arrangement of the original material, so that lists of guesses are matched against cards for which they were not intended[3]. The validity of a control made up of subsequent selections from the main data is itself questionable, but in any event this procedure has not always led to insignificant results[4]. Only the insignificant scores occurring with this procedure are cited as evidence for the validity of the probability calculations used; when significant scores occur, they are taken as evidence for more extra-sensory perception, etc.

(3) I did not suppose that 'success' in psychokinesis experiments assumed a contradiction; I am not at all sure what such a supposition would mean. I argued that the claim for psychokinesis could not

be substantiated by statistical significance alone, since the test of significance would be vitiated by any uncontrollable occurrence of statistically significant deviations in randomized data. If my critics will re-read the passage (pp. 11–21) referred to in ref. 6 [3] of my paper, they will see that the conclusions of the imaginary tea-cup experiment may not be drawn if we have to take into account a mysterious agency which might uncontrollably upset the random presentation of the cups of tea. If such an 'agency' could thus 'upset' a process of randomizing, then all our conclusions drawn through the statistical tests of significance would be equally affected, including the conclusions from the 'psychokinesis' experiments themselves. (How are the 'target numbers' for the die throws to be 'randomly chosen'? By more die throws?) To speak of an agency which can upset *any* process of randomization in an uncontrollable manner is logically equivalent to speaking of an inadequacy in the theoretical model for empirical randomness. The mysterious 'agency' which 'upsets' the randomizer, like the luminiferous ether of an earlier controversy, becomes, with the obsolescence of the calculus in which it occurs, a superfluous term.

(4) Finally, I did not in my paper make the inference that the results I obtained in matching columns of random sampling numbers invalidated the conclusions drawn from experiments in extra-sensory perception. On the contrary, it was from supposing that the conclusions drawn from experiments in extra-sensory perception were already invalid that I made the inference that similar data might be found elsewhere. In other words, the inference I drew was the converse of that which my critics have drawn for me.

G. Spencer Brown

Christ Church,
Oxford.

[1] *Nature*, **172**, 154 (1953).
[2] Coover, John E., "Experiments in Psychical Research" (Stanford Univ. Press, 1917). Richmond, Nigel, *J. Soc. Psych. Res.*, **36**, 577 (1952). Forwald, H., *J. Parapsychol.*, **16**, 282 (1952).
[3] Soal, S. G., and Goldney, K. M., *Proc. Soc. Psych. Res.*, **47**, 22 (1943).
[4] Soal, S. G., *Proc. Soc. Psych. Res.*, **46**, 152 (1942).
[5] Fisher, Ronald A., "The Design of Experiments" (London, 1947)

Sulphates in African Inland Waters

The communication on this subject by R. S. A. Beauchamp[1] emphasizes the need for agricultural experiments designed to explore possible sulphur deficiency in African soils. Mention is made of Storey and Leach's work on sulphur deficiency in Nyasaland which causes the tea yellows disease[2]. The Tukuyu district of the Southern Highlands province of Tanganyika is similarly affected, and since 1945, when D. W. Duthie of the Amani Research Station diagnosed the disease, application of sulphate of ammonia to tea soils has been a routine operation and has effectively controlled the disease.

When this Institute was started in 1950, a series of survey manurial experiments was planned, units of which are now in operation at Tukuyu and Mufindi (Southern Highlands, Tanganyika) and Kericho (Kenya Colony). A further extension to tea areas in Uganda is projected. These trials are based on the presence and absence of nitrogen, phosphoric acid, potash and elementary sulphur factorially combined. Nitrogen is supplied as sulphate of ammonia, potash as chloride, and phosphate as concentrated superphosphate in order to minimize the effect of adulterating sulphate ions; sulphur is applied in doses equivalent to those in the sulphate of ammonia dressings.

The two years results so far available appear in the annual report of the Institute. None of the experiments shows a response to sulphur, although it is known from other investigations being carried out that oxidation to available forms occurs within a matter of two to three months[3].

The Tukuyu results are of special interest in that the nitrogen effect is very marked and is of the same order as that shown in fertilizer experiments on tea in Ceylon[4]. It thus appears that the applications of sulphate of ammonia carried out during the six years prior to the start of the experiments have been sufficient to control the tea yellows disease during the following two years of experimentation, and that no limiting factor inhibiting specific nitrogen response has been operative.

So far, visits to the other tea districts in East Africa have not disclosed the characteristic symptoms of tea yellows, although tea has been grown in some districts for more than twenty-five years.

T. Eden

Tea Research Institute of East Africa,
Kericho, Kenya.
June 8.

[1] Beauchamp, R. S. A., *Nature*, **171**, 769 (1953).
[2] Storey, H. H., and Leach, R., *Ann. App. Biol.*, **20**, 23 (1946).
[3] Tea Research Institute of East Africa Ann. Rep. (1952).
[4] Eden, T., "Monographs on Tea Production in Ceylon" (1949).

Mr. R. S. A. Beauchamp states, ". . . the only sources of gypsum in East Africa are those contained in the Cretaceous deposits along the coast of Tanganyika Territory . . .".

Somaliland seems to have been overlooked, for it is geographically included in, however politically apart from, 'East Africa'.

In the eastern half of British Somaliland and extending into Italian Somalia is found what may be the greatest deposit of gypsum/anhydrite in the world. Of Middle Eocene age, it is roughly 1,000 ft. in thickness and extends over some 27,000 square miles in the Protectorate alone[1]. Mutual benefit would accrue if some of this 5,000 cubic miles of rock could be worked to supply the sulphate needs of other parts of Africa.

Regarding Mr. Beauchamp's remarks about the scarcity of African waters with a notable sulphate content, I have recently published[2] analyses of 145 water samples from wells and other sources in British Somaliland and surrounding areas, all but two including sulphate estimations. Naturally many show very high sulphates, not uncommonly between 2,000 and 3,000 parts per million. At the tiny village of Eik in the Somaliland Haud the well-water yielded me a figure of 4,440 p.p.m. of sulphate ions, with total dissolved solids of the order of 10,000 p.p.m. This must rank as one of the most saline waters that is anywhere regularly used for human drinking, and it is so scarce and precious that the wells are fitted with padlocked trap doors!

W. A. Macfadyen

Hope's Grove,
Tenterden,
Kent.

[1] Macfadyen, W. A., "The Geology of British Somaliland" (Crown Agents, 1933).
[2] Macfadyen, W. A., "Water Supply and Geology of Parts of British Somaliland" (Crown Agents, 1952).

FORTHCOMING EVENTS

Tuesday, September 29—Saturday, October 3

ASSOCIATION POUR L'ÉTUDE TAXONOMIQUE DE LA FLORE D'AFRIQUE TROPICALE (in the Departments of Forestry and Botany, South Parks Road, Oxford).—Second Plenary Meeting.

Friday, October 2

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. H. Murrell: "The Relationship of Ergonomics to Industrial Psychology".

Saturday, October 3

ASSOCIATION OF CLINICAL BIOCHEMISTS (joint meeting with the ASSOCIATION OF CLINICAL PATHOLOGISTS, in the Meyerstein Hall, Westminster Hospital Medical School, Horseferry Road, London, S.W.1), at 2.15 p.m.—Symposium on "Iron Metabolism" and other papers.

ENGINEERS' STUDY GROUP (at 20 Buckingham Street, Strand, London, W.C.2), at 2.45 p.m.—Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ANALYSTS (2), Assistant Experimental Officer grade (with recognized qualifications in chemistry)—The Secretary, Research Station, Long Ashton, Bristol (September 30).

ASSISTANT IN PHYSICAL CHEMISTRY in the Department of Chemistry, University College, Dundee—The Secretary, The University, St. Andrews (September 30).

MECHANICAL ENGINEER (with university degree in mechanical engineering) for investigational and design work in a Section responsible for all mechanical site services, boiler houses, water works, plant and services in buildings, and for erection of experimental equipment—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berks, quoting 1/66/7/90 (October 5).

SENIOR SCIENTIFIC OFFICER (preferably with first- or second-class honours degree in mechanical engineering, or equivalent qualification, and with postgraduate research experience, and also research experience on the creep and fatigue resistance of metals at high temperatures) IN THE MECHANICAL ENGINEERING RESEARCH LABORATORY, National Physical Laboratory, Teddington—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.53/53 (October 6).

ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, The University, Manchester (October 15).

VETERINARY OFFICERS and RESEARCH OFFICERS IN THE MINISTRY OF AGRICULTURE AND FISHERIES—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 244–245/53 (October 15).

SENIOR LECTURER IN THE DEPARTMENT OF BOTANY at the University of Natal, Pietermaritzburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 16).

TECHNICAL OFFICER (with recognized qualifications in fuel technology or chemical engineering, and practical experience, preferably in some branch of the fuel industry) IN THE HEADQUARTERS CARBONIZATION DEPARTMENT in London for duties concerned with technical developments in carbonization and allied fields and problems concerned with the quality of coke and carbonized fuels—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/685 (October 29).

CHAIR OF PHYSICAL CHEMISTRY—The Registrar, The University, Nottingham (October 31).

FOREST OFFICER to undertake teaching in all branches of Colonial Forestry and some part of undergraduate courses in forest management, mensuration and practical forestry—The Professor of Forestry, Imperial Forestry Institute, The University, Oxford (November 15).

RADCLIFFE TRAVELLING FELLOW IN ASTRONOMY—The Secretary, Board of Visitors, University Observatory, Oxford (March 31, 1954).

ABSTRACTOR (preferably with degree in engineering or physics, and knowledge of one or more of the following languages: Spanish, Italian, Swedish or French)—The Secretary, The British Shipbuilding Research Association, 5 Chesterfield Gardens, Curzon Street, London, W.1.

ASSISTANT MECHANICAL ENGINEER (with administrative and organizing experience) with the Sudan Gezira Board to take charge of a new project, and be prepared to work on experimental lines—The Sudan Agent in London, Sudan House, Cleveland Row, St. James's, London, S.W.1, quoting "Assistant Mechanical Engineer 2412".

ENGINEERS and PHYSICISTS, SENIOR SCIENTIFIC OFFICER and SCIENTIFIC OFFICER grades (Ref. A.246/52A) (with first- or second-class honours degree in physics or engineering, or high professional attainments such as corporate membership of appropriate professional institution, with suitable experience and responsibility); EXPERIMENTAL OFFICER and ASSISTANT EXPERIMENTAL OFFICER grades (Ref. A.247/52A) (with university degree in science, engineering or mathematics, or graduate membership of appropriate professional institution) in Royal Naval Scientific Service Experimental Establishments in the London, Portsmouth and Weymouth areas, and in Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No.

LECTURER (preferably with interest in the field of protein chemistry) IN BIOCHEMISTRY at the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

LECTURER (with A.M.I.Chem.E. and/or degree qualification, and preferably with industrial experience) IN CHEMICAL ENGINEERING, and an ASSISTANT (with A.I.M. and/or degree qualification) IN METALLURGY—The Registrar, Loughborough College of Technology, Loughborough, Leicestershire.

LECTURER and an ASSISTANT LECTURER IN MECHANICAL ENGINEERING—The Professor of Mechanical Engineering, Imperial College, London, S.W.7.

MECHANICAL and ELECTRICAL ENGINEERS, (*a*) Main grade (with university degree or equivalent diploma in electrical and/or mechanical engineering, and at least a two year apprenticeship); (*b*) Assistant grade (Graduate or Corporate Membership of the Institutions of Mechanical or Electrical Engineers, with appreciable electrical engineering experience and at least three years apprenticeship) in the Air Ministry, Works Department, for design, operation and maintenance of ground mechanical and electrical works services on R.A.F. stations at home and overseas and Civil Aviation stations—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.290/52A.

MECHANICAL ENGINEER (corporate member of either the Institution of Electrical or Mechanical Engineers, or equivalent qualifications, and with experience in Public Water and Electricity Supply undertakings, preferably overseas) IN THE PUBLIC WORKS DEPARTMENT, Sudan Government—The Sudan Agent in London, Sudan House, Cleveland Row, St. James's, London, S.W.1, quoting "M/Engineer 1824".

METEOROLOGISTS (2) in the Gold Coast, (*a*) (with honours degree in physics or mathematics, and not less than seven years experience in the Meteorological Office or Meteorological Branch of the Royal Navy, with some service in the tropics, and fully conversant with I.C.A.O. procedures) to supervise Accra Forecasting Office and related work of outstations, etc.); (*b*) (with honours degree in physics or mathematics, and experience in climatology, training of meteorological staff and forecasting) for work primarily on climatological investigation and research, and to assist in proper scientific training of local staff—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE. 57/13/02.

SCIENTIFIC OFFICERS (Ref. A.230/53A) (*a*) ELECTRICAL ENGINEERS or PHYSICISTS (with first- or second-class honours degree or equivalent qualifications) for work on centimetric transmitting and recentring equipment; (*b*) THEORETICAL PHYSICISTS or MATHEMATICIANS (with first- or second-class honours degree or equivalent qualifications) for work on radio propagation, radio frequency measurements, aerials and radiation problems. EXPERIMENTAL OFFICERS (Ref. A.231/53A) (with H.S.C. Science) for development of electronic equipment, radio frequency measurements, especially at centimetric wave-lengths, and other detailed technical investigations, IN THE RADIO DIVISION, Royal Aircraft Establishment, Farnborough, Hants—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No.

SENIOR CHEMICAL ENGINEER (with A.R.I.C. or A.M.I.Chem.E., or equivalent, and at least three years experience in an industrial research organization) in the Division of Atomic Energy (Production), Sellafield, Cumberland, to be responsible for a section concerned with development of new chemical processes including design and operation of pilot plants—The Ministry of Supply, Department of Atomic Energy (Production), Risley, Warrington, quoting 499.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with first- or second-class honours degree in mathematics or astronomy, and an interest in celestial mechanics, spherical astronomy or numerical computation, and preferably with research experience in one of these subjects) IN H.M. NAUTICAL ALMANAC OFFICE, Royal Greenwich Observatory, Herstmonceux, Sussex, for work in the fields of celestial mechanics and positional astronomy—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.252/53A.

SOIL CHEMIST, PLANT BREEDERS (2), AGRONOMIST, STATISTICIAN, CIVIL ENGINEERS (Soil Conservation Section) (3), and AGRICULTURAL ENGINEERS (Engineering Division) (2), (with appropriate honours degree or equivalent qualification) IN THE RESEARCH DIVISION, Ministry of Agriculture, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, St. James's, London, S.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Report of the Pest Infestation Research Board, with the Report of the Director of Pest Infestation Research for the year 1952. Pp. iv+44+4 plates. (London: H.M. Stationery Office, 1953.) 2*s.* net. [97

Bulletin of The British Museum (Natural History). Geology, Vol. 2, No. 1: The Deer of the Weybourn Crag and Forest Bed of Norfolk. Pp. 96. (London: British Museum (Natural History, 1953).) 25*s.* [97

Department of Scientific and Industrial Research. Report of the Forest Products Research Board, with the Report of the Director of Forest Products, for the year 1952. Pp. vi+62+8 plates. (London: H.M. Stationery Office, 1953.) 3*s.* net. [97

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 908, Vol. 246: An Investigation of Whistling Atmospherics. By L. R. O. Storey. Pp. 113–141. 6*s.* 6*d.* No. 909, Vol. 246: The Growth of the High-Frequency Electrodeless Discharge. By G. Francis and A. von Engel. Pp. 143–180. 9*s.* Series B: Biological Sciences. No. 645, Vol. 237: Studies of the Carotid Rete and its Associated Arteries. By P. M. Daniel, J. D. K. Dawes and Marjorie M. L. Prichard. Pp. 173–208+plates 12–19. 8*s.* No. 646, Vol. 237: The Pleistocene Deposits of the Area between Coventry, Rugby and Leamington and their Bearing upon the Topographic Development of the Midlands. By F. W. Shotton. Pp. 209–260. 13*s.* 6*d.* (London: Cambridge University Press, 1953.) [97